FM 3-10

DEPARTMENT OF THE ARMY FIELD MANUAL

CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY
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CHEMICAL AND BIOLOGICAL WEAPONS EMPLOYMENT

CHAPTER 1
INTRODUCTION

1. Purpose

This manual provides guidance to commanders and staff officers in the employment of chemical and biological weapons. It contains a brief summary of background knowledge of chemical and biological agents and munitions and the procedures to be followed in planning their employment.

2. Scope

a. General. Considerations are limited to chemical and biological agents and delivery systems that are type-classified or expected to be type-classified during the period ending December 1965. The chemical agents are nerve agent GB, nerve agent VX, and blister agent HD. The agent delivery means are artillery and mortar shells, rocket and missile warheads, aircraft bombs, and spray devices. FM 3–10A contains the classification and characteristics of biological agents and information on biological munitions and delivery systems. Troop safety considerations are presented. This manual is applicable to nuclear and nonnuclear warfare.

b. Chemical Agents. Chapters 3 through 8 contain a discussion of chemical agents and their characteristics; factors affecting the employment of chemical agents; chemical munitions and delivery systems and the concepts for their employment; and target analysis, fire planning, and logistical considerations. Methods of chemical target analysis presented are suitable for fire planning and casualty assessment at all echelons of command having chemical fire planning and assessment responsibilities.

c. Biological Agents. Chapters 9 through 13 contain a discussion of biological agents and their characteristics; factors affecting the employment of biological agents; biological munitions and delivery systems and the concepts of their employment; and target analysis, effects assessments, and logistical considerations. Only the antipersonnel effects of biological agents are considered. The methods of biological weapons target analysis presented are suitable for biological fire planning and casualty assessment. The unique character of biological munitions supply and field management is presented.

d. Reliability. The data and procedures presented in this manual have been extracted or derived from official studies and from research and development documents. The potential performance of materiel is based on field trial data with simulants and selected live agents and on theoretical calculations and assumptions developed from mathematical models. The procedures are therefore subject to change as may be required by future developments or refinements. It should be noted that the flow of a chemical or biological agent cloud over the terrain cannot be predicted with a high degree of precision. This is due principally to the inability to predict accurately the prevailing atmospheric conditions of the area under consideration with respect to the diffusion and dissipation of an agent cloud. Nevertheless, the methods and procedures presented here provide information with sufficient accuracy to be used with reasonable confidence.

e. User Comments. Users of this manual are encouraged to submit recommended changes or comments to improve the document. Comments should be keyed to the specific page, paragraph, and line of the text in which change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded direct to the Commandant, U.S. Army Chemical Corps School, Fort McClellan, Ala.

3. The Role of Chemical Agents in Military Operations

a. Chemical weapons increase the flexibility of the integrated weapons systems and place at the commander's disposal a highly effective means of conducting antipersonnel operations.

b. In the conduct of military operations involv-

ing chemical weapons, some factors that should be considered are—

(1) The chemical agents discussed herein do not destroy materiel. On the contrary, they allow the physical preservation of industrial complexes, cultural institutions, lines of communications, and other facilities and materiel that may be useful to friendly forces or that merit preservation for political or economic reasons.

(2) Chemical munitions do not produce physical obstacles to maneuver, since they cause minimal destruction, blowdown, rubble, and similar barriers. Agents that produce a persistent effect, however, will create a hazard to friendly troops.

(3) Chemical agents may be employed to produce a variety of effects ranging from harassment to lethality.

(4) Toxic chemical clouds penetrate fortifications and similar structures that are not airtight.

(5) Because of their area coverage effect, chemical agents, used in mass, are particularly effective in attacking targets whose location is not precisely known.

(6) Chemical munitions are particularly effective for producing casualties among dug-in personnel who are not provided with chemical protection.

(7) Chemical agents increase the flexibility of the entire spectrum of firepower available to the commander.

(8) Chemical agents may be used to follow up and exploit advantages gained by other means.

(9) Because the effectiveness of chemical agents on the target is influenced by the type and quantity of agent employed and by the method of dissemination, meteorological factors, conditions of the target, and protection and training of enemy troops, it is difficult to predict the results of employment accurately.

(10) Chemical agents may produce hazards to friendly forces because of residual contamination and cloud movement.

4. Chemical Agents

a. The following three type-classified chemical agents provide commanders flexibility in their employment of chemicals.

(1) Nerve agent GB is a rapid-acting lethal agent that is used primarily for respiratory effects against unprotected personnel and for surprise attack against personnel having masks available.

(2) Two agents are used in circumventing the protective mask.

(*a*) VX is a slow-acting lethal nerve agent when absorbed percutaneously. If inhaled as an aerosol or vapor, VX acts as rapidly as GB and is more toxic.

(*b*) HD is a slow-acting casualty agent with a limited lethal effect. It attacks the skin in liquid or vapor form and is also effective by inhalation.

b. The following figures describe GB and HD in more detail. Detailed information on VX is contained in FM 3–10A. More comprehensive data on chemical agents are in TM 3–215.

1. Primary use	Nonpersistent, rapid-acting lethal agent used primarily for respiratory effect.
2. Average time to incapacitation	15 minutes after exposure to an incapacitating dosage; for lethal dosages, death in 5 minutes after appearance of symptoms if untreated.
3. Duration of incapacitation	1 to 5 days for return to duty. (30 to 60 days for return to normal blood cholinesterase level.)
4. Signs and symptoms	Tightness of chest, pinpointing of eye pupils, dimness of vision, excessive sweating, drooling; followed by tension, giddiness, tremors, confusion, slurred speech, weakness, convulsions, and death.
5. Physiological effects	Nerve poison; slow detoxification by body (60 days); effects of successive small dosages considered cumulative for short periods of time (weeks).
6. Route of entry	Inhalation; percutaneous entry by liquid or high vapor concentration is unlikely in the field because of the high dosage required.
7. Protection	Mask against vapor; protective clothing against liquid agent.
8. Limitations	Mask offers adequate protection against vapor for trained and warned personnel.
9. Duration of hazard	The area in and around shell or bomb craters will be contaminated and will remain a hazard to unprotected personnel for periods ranging from 6 hours to several days.
10. Physical properties	Clear, colorless, odorless liquid; freezing point minus 56° C (−69° F.); boiling point 147° C (297° F.); evaporates at approximately the same rate as water.

Figure 1. Characteristics of nerve agent GB.

1. Primary use	To cause delayed casualties by liquid and vapor effect on the skin and eyes and by vapor effect through the respiratory system.
2. Average time to incapacitation	Eye effect 3 to 12 hours; skin effect 3 to 24 hours.
3. Duration of incapacitation	Eye effect 1 to 7 days; skin effect 1 to 4 weeks.
4. Signs and symptoms	Inflammation of eyes; redness of skin; blistering; ulceration.
5. Physiological effects	Produces blisters and destroys tissues.
6. Route of entry	Skin absorption of vapor or liquid and inhalation of vapor.
7. Protection	Mask, ointment, and protective clothing.
8. Limitations	Limited effectiveness in freezing weather; greater dosages are required for casualty production than are required with GB or VX.
9. Duration of hazard	36 hours to several days. See figure 2.1d.
10. Physical properties	Clear oily liquid with garliclike odor; moderately volatile; freezing point 14° C. (57° F.); boiling point 228° C. (442° F.).

Figure 2. Characteristics of blister agent HD.

Times given indicate approximate time after contamination that personnel may operate in the area

Task	Terrain	Protection (Based on expenditures between 240 and 1,200 pounds of HD per hectare)			
		With protective clothing and wearing masks		Without protective clothing [1]	
		Temperature		Temperature	
		16°–27° C. (60°–80° F.)	Above 27° C. (80° F.)	16°–27° C. (60°–80° F.)	Above 27° C. (80° F.)
		Hours	*Hours*	*Days*	*Days*
TRAVERSAL [2] (Walking across area up to 2 hr)	Bare soil, sand, or short grass	0	0	[3] 1½	[3] 1½
	Low vegetation	4	2	[3] 1½	[3] 1½
	High vegetation, including jungle and heavy woods.	12	6	[3] 4	[3] 2
ADVANCE UNDER FIRE (Contact with ground, 1 hr; total time in area, 2 hr).	Bare soil or low vegetation	24	8	[3] 3	[3] 2
	High vegetation, including jungle and heavy woods.	48	24	[3] 6	[3] 4
OCCUPATION (Without hitting ground, 24 hr)	Bare soil or low vegetation	1	1	[4] 4	[4] 3
	High vegetation, including jungle and heavy woods.	1	1	[4] 4	[4] 3
OCCUPATION (Involving advance under fire, 24 hr).	Bare soil or low vegetation	24	8	[4] 4	[4] 3
	High vegetation, including jungle and heavy woods.	48	24	[4] 6	[4] 4

[1] For men walking in a contaminated area for 2 hours without protective clothing, the limiting factor is the vapor.
[2] For men with protective clothing, when traversal is made in daylight and areas of heavy contamination can be avoided or decontaminated, the times can be reduced to about one-half of those indicated above.
[3] Wearing masks.
[4] Not wearing masks.

Figure 3. Duration of HD hazard in target area.

CHAPTER 2

PRINCIPAL FACTORS AFFECTING CHEMICAL AGENT EMPLOYMENT

Section I. INTRODUCTION

5. General

Some of the principal factors that determine the behavior and tactical effectiveness of chemical agents are the method of dissemination, the weather, and the terrain in the target area. Other important factors are discussed in chapters 5 through 7. These factors are the level of physical and personal protection of target personnel, the level of training of enemy troops, and the target characteristics.

Section II. METHODS OF DISSEMINATION

6. Bursting-type Munitions

These munitions include bombs, warhead bomblets, rockets, and artillery and mortar shells. When these munitions burst on target, most of the agent is disseminated as liquid splash, vapor, or aerosol. Of the remainder of the agent, part is driven into the crater formed by the burst, and part is decomposed by the explosion. When there are a number of bursts in the target area and the conditions are favorable, clouds from adjacent bursts merge, thus forming a continuous cloud. In the case of an air burst, there is no loss due to cratering effect, and a maximum of agent return is achieved. If the agent is being disseminated in aerosol or vapor form, the greater agent return will be offset by the fact that much of the agent will remain well above ground level.

7. Spray-Type Munitions

GB, HD and VX chemical agents may be disseminated by spray devices mounted on aircraft. A toxic chemical agent spray mission is most effective when released simultaneously by the required number of aircraft flying at the desired height of release. A sample casualty level pattern produced by aircraft spray is shown in figure 4.

Section III. METEOROLOGICAL FACTORS

8. General

The reliability of the prediction of chemical agent cloud behavior for a chemical operation is dependent upon the completeness and accuracy of forecasts of related meteorological conditions. Temperature, temperature gradient, wind, and precipitation are the major meteorological factors to consider in chemical operations, and of these the temperature gradient has the greatest influence on chemical munitions requirements. Though these factors influence the effectiveness of chemical agents deposited on the ground, they are of far greater importance because of their effect upon the behavior of chemical clouds. In the assessment of the possible effects of toxic chemical clouds, a target analyst cannot rely solely upon rules of thumb, bare meteorological data provided, and the basic procedures given in this handbook for the estimation of munitions requirements and agent effects. The analyst must also consider the total environment of chemical clouds over the entire life span of their possible effectiveness. Based on experience, study, and the best possible information on meteorology and terrain in the zone of operations, the analyst must determine the possible avenues of toxic cloud travel and the

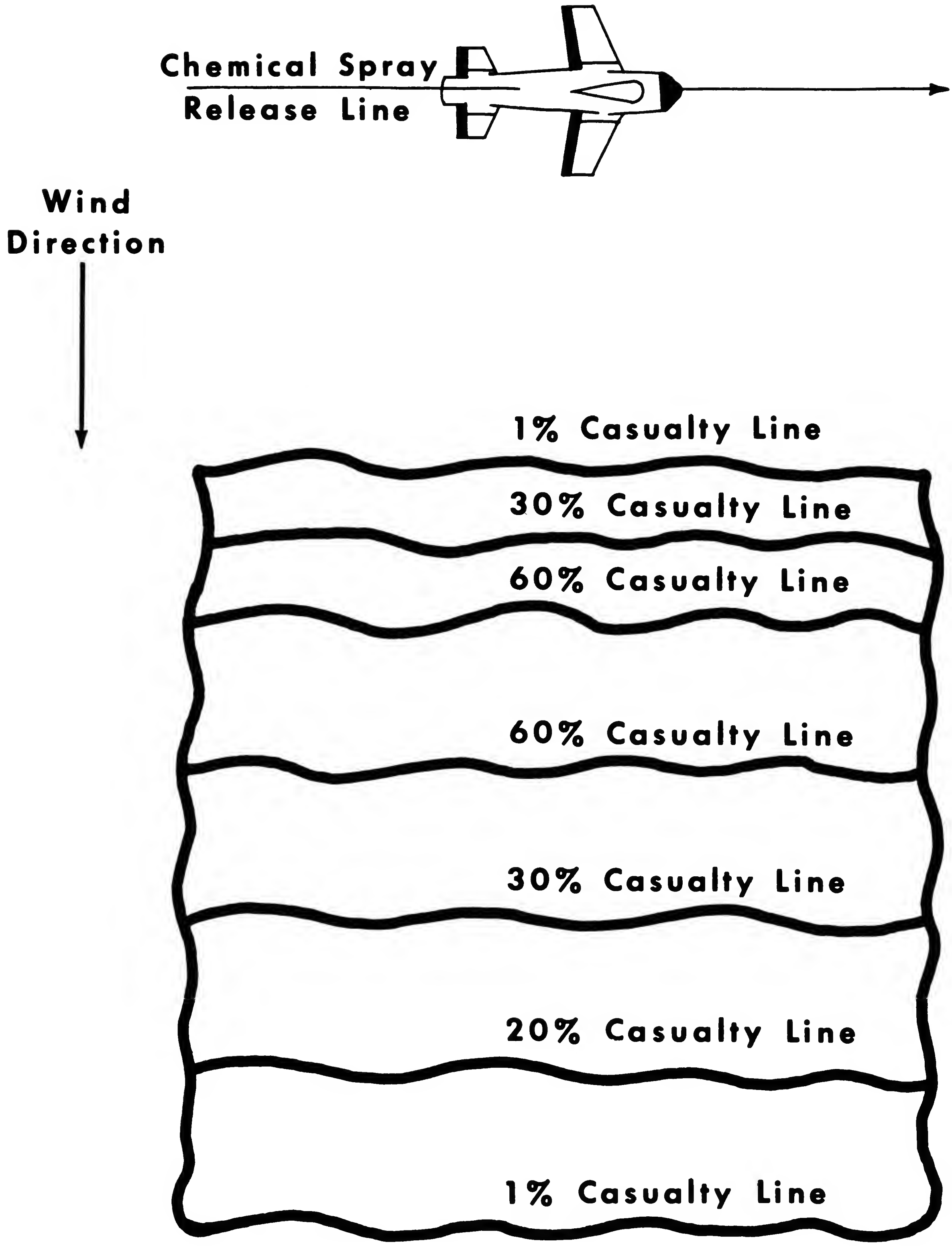

Figure 4. Elevated line source (Aircraft spray tank) casualty level contour pattern.

life expectancy of the cloud. He must consider overall meteorological effects as well as those factors operating in the target area. He must consider the effects of probable meteorological changes as they affect the chemical cloud over a period of time. Publications such as TM 3-240 give general guidance on weather and terrain effects, but it must be remembered that peculiarities of particular areas must also be considered.

9. Sources of Meteorological Information

a. The basic source of weather data is the Air Weather Service. This service will provide general meteorological data, give general predictions of weather in the zone of operations, and furnish detailed weather information as requested. Supplementing the Air Weather Service are artillery meteorological stations from which basic weather data can be obtained if requested.

Additional micrometeorological characteristics of the zone of operations are obtained through the following methods:

(1) Aerial reconnaissance and observations.
(2) Ground reconnaissance and observations.
(3) Observations of fog, smoke, and dust in the zone of operations.
(4) Field expedient methods for obtaining micrometeorological data in the vicinity of the target area.
(5) Statistical studies of weather in the theater of operations.

b. A suggested format for transmission and recording of basic weather data is illustrated in appendix II. It is emphasized that in chemical target analysis, the weather predictions are required for a period of time after the attack as well as for the time of the chemical attack.

c. Normally, Air Weather Service detachments are stationed at field army, corps and division headquarters. From these sources a target analyst may obtain weather data and weather briefings, or he may request detailed operational and planning forecasts and climatological information.

10. Temperature

The rate of evaporation of chemical agents increases as the temperature rises. High temperatures cause personnel to perspire more freely, thus opening the pores of the skin and accelerating penetration of the skin by the agent. At low temperatures, extra layers of clothing increase the barrier to the skin.

11. Temperature Gradient

The temperature gradient is an expression of the difference in air temperature at two levels. In the United States Army, it is determined by subtracting the air temperature (Fahrenheit) measured one-half meter above the ground from the air temperature 2 meters above the ground. The three characteristic conditions that are associated with the temperature gradient follow:

a. Lapse. A decrease in air temperature with an increase in height is known as a *lapse* condition. Such a condition normally exists on a clear or partially clear day and is characterized by heat turbulence. It is the least desirable condition for chemical operations because of rapid dissipation of agent clouds.

b. Inversion. An increase in air temperature with an increase in height is known as an *inversion* condition. This condition exhibits a minimum of turbulence and usually exists on a clear or partially clear night or early morning. This is the most desirable condition for chemical operations since the agent cloud tends to remain in the cooler layers of the air near the ground.

c. Neutral. A condition intermediate between lapse and inversion is known as a *neutral* condition. Such a condition prevails when there are small differences in temperature at the two levels and usually exists on heavily overcast days or nights, and shortly after sunrise and near sunset.

12. Wind

The wind is also an important weather element affecting the field behavior of chemical clouds. Of the wind characteristics, velocity and direction have greatest influence. Both characteristics are influenced by terrain and temperature gradient.

a. Velocity. Air moving over an irregular surface sets up eddies, or mechanical turbulence. This turbulence is similar to heat turbulence in that it acts to dissipate a chemical cloud. High wind velocities also cause the agent cloud to pass rapidly over the target area, thus reducing the exposure time. Some air movement is desired to blend the individual clouds of agent formed by each shell burst into a uniform cloud covering the target. Ideal wind velocities for chemical operations are 3 to 9 knots (approximately 6 to 16 kilometers per hour). Wind velocities in excess of 16 knots (approximately 30 kilometers per hour) are not suitable for nonpersistent effects.

b. Direction. Wind directs the travel of a chemical cloud. This fact must be considered in the release of an agent for coverage of a particular target and in the determination of the downwind hazard to friendly troops. The wind direction is the direction from which the wind blows and is expressed in terms of azimuth in mils or degrees.

13. Precipitation

Precipitation has an adverse effect on the behavior of chemical agents, since rain will wash away the liquid agent contamination and snow will cover it. Precipitation also washes agent vapors or aerosol clouds from the air and destroys some agents by hydrolysis.

Section IV. TERRAIN CONDITIONS

14. Contour

The contour of the ground alters the direction of cloud travel and may break a cloud into parts. Depressions and draws will retain portions of an agent cloud after open flat areas have been swept clear by the wind. Agent vapor which has infiltrated buildings and fortifications has a tendency to remain therein for prolonged periods after passage of the agent cloud. TM 3–240 gives detailed information on the effects of terrain on the field behavior of chemical agents.

15. Surface

Cloud size, crater size, degree of liquid contamination, and penetration of impact-detonating munitions are influenced by ground surface.

a. Soft Soil. A soft surface allows a shell to penetrate to greater depths before it explodes. This results in a greater percentage of agent being driven into the crater wall and in an upward funneling of agent cloud, thus reducing surface effectiveness.

b. Hard Soil. A hard surface reduces penetration and cratering and minimizes the loss in the crater wall, thus enhancing the effectiveness of chemical agents.

c. Porous Soil. Porous soils (sand) absorb liquid agents, thereby slowing evaporation and reducing the hazard of liquid agent contamination.

16. Vegetation

Liquid agent spread on vegetation normally presents a greater contact hazard to troops than does agent on bare soil or hard surfaces. More effective agent cloud concentrations can be built up in the stable, protected air of a wooded area.

CHAPTER 4
CHEMICAL MUNITIONS AND DELIVERY SYSTEMS

23. Cannon-Delivered Chemical Munitions

Cannon-delivered chemical munitions consist of shells filled with toxic agents and fitted with fuze and burster. The shells within this class differ mainly in type and quantity of agent fill, type of fuze, caliber, and agent-to-burster ratio. The delivery systems differ mainly in angle of fire, flexibility, mobility, rate of fire, and time for delivery. Cannon artillery firing chemical munitions are capable of cross-country maneuvering and deep penetration.

24. Rocket-Delivered Chemical Munitions

This class of chemical munitions consists of chemical-filled warheads, either permanently attached to rockets or shipped separately for assembly at the launching site. Either type is capable of indirect fire. They differ in type and quantity of agent, fuzing, range, type warhead, launching capability, rate of fire, and response time. Small caliber chemical rockets are large-volume, rapid rate of fire weapons used for close support. Large caliber chemical rockets are used for single-round attack of targets at long ranges, functioning by air release of many self-dispersing, impact-functioning bomblets. Both types are suitable for large area coverages (areas greater than five hectares*) and have the same disadvantage of revealing their emplacement by flash and dust. Navy chemical rockets are used primarily for close support of landing operations or attack of shore targets. They may be used for attack of surface craft.

*One hectare is a 100-meter square.

25. Guided-Missile-Delivered Chemical Munitions

Chemical warheads are available for certain guided missiles. These warheads contain chemical agent filled bomblets and are interchangeable with other type warheads for the missile. The delivery system is limited in availability of missiles, rate of fire, response time, and close support capability. These delivery systems are used primarily for engaging targets at long range.

26. Aircraft-Delivered Chemical Munitions

Chemical munitions in this class consist of aerial bombs and clusters. They differ in weight, type and quantity of agent fill, single or multiple bombs, fuzing, and accuracy. Delivery is accomplished by fighters or bombers, which differ in range of flight, payload, accuracy, time for delivery, and type of targets engaged. Both the Navy and the Air Force have the capability for delivery of chemical bombs. See FM 3–10A and TM 3–200A for classified information.

27. Chemical Land Mines

Chemical land mines are filled with HD or VX and are used to aid in the establishment of barriers. No procedures are given for target analysis when chemical land mines are employed.

28. Chemical Munitions and Delivery Systems

A summary of characteristics and performance data of chemical munitions and delivery systems is tabulated in figure 5 for ready reference by the target analyst. Where no data appear, the information is not available or is of limited reliability. Where asterisks appear in the columns, the data are close approximations derived from developmental equipment.

Line	1 Munition	2 Agent	3 Delivery system	4 User	5 Employment data (a) Range (1) (Meters) (2) Maximum	Minimum	(b) Error	(c) Fuze (Capability)
1	Shell, M2A1	HD	4.2-inch Mortar	US ARMY USMC	3,930	180	←Obtain from delivery unit or appropriate firing tables→	M8PD
2	Shell, M360	GB	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140	862		M508PD
3	Shell, M60	HD	105-mm Howitzer, M2A1, M2A2, M4, M4A2, M52.	US ARMY USMC	11,140			M51A5PD
4	Shell, M121	GB	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M508PD
5	Shell, M110	HD	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			M51A5PD
6	Shell, T__(M121)	VX	155-mm Howitzer, M1, M1A1, M44.	US ARMY USMC	14,950			T76E6VT [1]
7	Shell, M122	GB	155-mm Gun, M2, M53	USMC	23,500			M508PD
8	Shell, M104	HD	155-mm Gun, M2, M53	USMC				M51A5PD
9	Shell, Gas, 175-mm	GB	M107 Gun (SP)	US ARMY	31,500	180		
10	Shell, Gas, 175-mm	VX	M107 Gun (SP)	US ARMY	31,500	180		VT-M514A1
11	Shell, T174	GB	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC	16,930			M51A5PD
12	Shell, T174	VX	8-inch Howitzer, M2, M2A1, M55.	US ARMY USMC.	16,930			T2061VT
13	Rocket, M55, 115-mm (BOLT)	GB	Launcher, M91	US ARMY USMC.	10,970	2,740		M417PD
14	Rocket, M55, 115-mm (BOLT)	VX	Launcher, M91	US ARMY USMC.	10,970	2,740		T2061VT
15	Warhead, M79, 762-mm (HONEST JOHN).	GB	Rocket, M31A1C Launcher, M386.	US ARMY USMC.	24,960	8,500		T2075 Mech Time
16	Warhead, E19R2, 762-mm (HONEST JOHN).	GB	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
17	Warhead, E19R2, 762-mm (HONEST JOHN).	VX	Rocket, XM50 Launcher, M386.	US ARMY USMC.	33,830	8,500		T2075 Mech Time
18	Warhead, E20, 318-mm (LITTLE JOHN).	GB	Rocket, XM51 Launcher, XM80.	US ARMY USMC.	18,290	3,200 [1]		T2075 Mech Time
19	Warhead, E21, (SERGEANT)	GB	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
20	Warhead, E21, (SERGEANT)	VX	Rocket, Launcher	US ARMY	139 km	50 km	304m	Preset Radar
21	Bomb, M34A1, 1000-lb, Cluster	GB	Fighter, Bomber	USAF	Range of Aircraft.		←Obtain from delivery unit→	M152E3 Mech Time
22	Bomb, MC-1, 750-lb	GB	Fighter, Bomber	USAF	Range of Aircraft.			M905BD
23	Projectile, 5"/38, MK53, MOD O	GB	5-inch Gun	US NAVY	16,450			MK29MOD3PD
24	Projectile, 5"/54, MK54, MOD O	GB	5-inch Gun	US NAVY	19,200			MK30MOD3PD
25	Warhead, Rocket, 5" MK40, MOD O.	GB	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
26	Warhead, Rocket, 5", MK40, MOD O.	HD	Launcher, MK 105 Rocket, M40, MOD O.	US NAVY	4,200			MK30MOD3PD
27	Bomb, MK94, MOD O	GB	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M103A1ND M195 BD (IMPACT).
28	Bomb, M70A1	HD	Fighter, Bomber	US NAVY	Range of Aircraft.			AN-M158ND (IMPACT).
29	Mine, Land, Chemical, M23	VX	N/A	US ARMY	N/A	N/A	N/A	
30	Mine, Land, Chemical, One-Gallon.	HD	N/A	US ARMY	N/A	N/A	N/A	

See notes at end of figure.

Figure 5. Chemical munitions and delivery systems.

5 Employment data—Continued						6 Functioning and physical characteristics of CML munitions				
(d)		(e)	(f)	(g)	(h)	(a)	(b)	(c)	(d)	(e)
Time for delivery		Organization	Rate of fire per weapon	Height of burst	Diameter (meters) of impact area (single rd) [2]	Weight of munition (kg)	Weight of agent (kg)	Effective weight of agent (kg) [3]	Functioning efficiency of munition (percent)	Agent dissemination efficiency
(1) Preplanned	(2) Target of opportunity									
----	----	6 Mort/Plt 8 Mort/Btry	30 Rds/2 min 105 Rds/15 min	GND	16	10.8	2.72	----	99	
----	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	27	16.1	.739	----	99	
----	1–3 min	6 How/Btry	6 Rds/½ min 18 Rds/4 min	GND	11	15.2	1.22	----	99	
----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	49	45.9	2.95	----	99	
----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	GND	20	42.0	4.4	----	99	
----	1–5 min	6 How/Btry	3 Rds/½ min 12 Rds/4 min	20m [1]	----	45.9	2.95	----	99	
----	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	49	45.9	2.95	----	99	
----	1–5 min	4 Gun/Btry	2 Rds/½ min 8 Rds/4 min	GND	22	43.0	5.31	----	----	
		4 Gun/Btry	----	GND	----	66.8	6.68	----	----	
----	----	4 Gun/Btry	----	GND	----	66.8	6.04	----	----	
----	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min	GND	76	97.0	7.12	----	99	
----	½–6 hr	4 How/Btry	6 Rds/4 min 10 Rds/10 min.	20m [1]	----	97.0	7.12	----	99	
----	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	GND	46	26.4	4.80	----	99	
----	30 min	36 Lchr/Bn	45 Rkt/Lchr/15 sec.	20m [1]	----	26.2	4.54	----	99	
----	15 min	2 Lchr/Bn	2/Hr	Variable	Variable	737	177.5	104.8	95	62 percent.
----	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210	171	95	86 percent.
----	15 min	2 Lchr/Btry	2/Hr	Variable	Variable	568	210			
----	15 min	4 Lchr/Btry	2/Hr	Variable	Variable	119	30			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
15 min	120 min	4 Lchr/Bn	2/Day	Intervals of 1,524m.	Variable	744	190			
----	15 min +flight time.	----	2–6/Ftr. 4–18/Bmbr.	Variable	170	513	89.6	----	90	
----	15 min +flight time.	----	2–6/Ftr. 4–27/Bmbr.	GND	127	322	99.9			
----	----	----	----	GND	35	25.1	1.47			
----	----	----	----	GND	40	29.1	2.02			
----	----	----	48 Rkt/Lchr/ 1 min	GND	49	22.9	2.18			
----	----	----	48 Rkt/Lchr/ 1 min	GND	----	----	----			
----	----	----	----	GND	90	222	49.8			
----	----	----	----	GND	29	58.0	272			
----	----	----	----	----	----	10.50	5.23			
----	----	----	----	----	----	5.45	4.50			

[1] Estimated.
[2] Instantaneous agent area coverage 30 seconds after detonation.
[3] Values are the product of values given in columns 6(*b*), 6(*d*), and 6(*e*). Since values for 6(*e*) are not available, values for 6 (*c*)cannot be computed at this time.

Figure 5.—Continued

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CHAPTER 6

COMPUTATIONS INVOLVING MUNITIONS REQUIREMENTS, AREA COVERAGE, AND PERCENT CASUALTIES

Section I. DETAILED METHOD

40. General

As previously discussed, the meteorological and terrain conditions greatly influence agent effects. The methods of computation presented here involve the use of specific information relating to these factors as they affect expenditure requirements, area coverage, and casualty predictions. The analyst should bear in mind that, although these methods are in general agreement with test information, they, like those for all other weapons systems, are based on statistical predictions and technical estimates and as such cannot be expected to provide great accuracy in specific situations.

41. Analysis Variables

a. In order to use this system of analysis, the analyst must know (or estimate):

(1) Agent to be used.
(2) Terrain and vegetation in the target area.
(3) Temperature, temperature gradient, wind speed and direction, and precipitation in the target area at the proposed time of employment.
(4) State of training of and protective equipment available to personnel in the target area.

b. Knowing the factors in *a* above and any two of the three variables—target area, percent casualties desired among unprotected personnel, and munitions requirements (in terms of number of 155-mm howitzer rounds)—the analyst can determine the third variable.

c. Delivery error is not considered in computation of munitions requirements nor is it used to establish probabilities of achieving the desired area coverage, since a suitable method for its consideration is yet to be developed.

d. In estimating the capability of division cannon artillery to deliver chemical agent on a target, using maximum rates of fire, figure 9, the lack of time to shift and relay the guns limits area coverage capabilities. A rule of thumb for cannon artillery when these rates of fire are employed is: assign a 105-mm battery a target of no larger than 5 to 7 hectares; assign a 155-mm or 8-inch battery a target of no larger than 7 to 10 hectares. While cannon artillery may be capable of firing a weight of agent that will be theoretically adequate for an area, the problem of distribution will limit the actual area coverage. Normally, targets of larger size will be broken down into more than one battery fire mission. Otherwise, lower rates of fire will have to be used to allow time for shifting and relaying of guns.

e. When multiple bomblet or multiple rocket systems are employed, the impact pattern of the weapon and the casualty effect of the agent delivered must be considered to insure that the pattern is suitable for the target and that the desired casualty level will be achieved. This is accomplished through the following process:

(1) Determine the size and shape of the weapon impact pattern.
(2) Determine if the impact pattern is suited to the target size and shape.
(3) Determine the number of 155-mm chemical equivalents needed to give the desired effect on the target area.
(4) Determine the number of weapons needed to give at least the required number of equivalents.
(5) In the case of multiple bomblets, consider the height of release, since it affects the size of the area covered and the casualty level in that area.

42. Computation of Munitions Requirements

The five steps involved in the computation of munitions requirements are enumerated below

and are discussed in detail in subsequent paragraphs:

a. Determination of target area.

b. Determination of degree of protection available to the enemy and conversion of desired casualty level to a corresponding casualty level that would be produced for unprotected personnel (fig. 11). This determination is required only for other than surprise attack.

c. Determination of the sum of effects components for the particular agent as related to the target conditions.

d. Determination of munitions requirements in terms of 155-mm howitzer equivalents.

e. Determination of unit capabilities to deliver munitions required.

43. Example Problems—Employment of GB and VX

The detailed procedures involved are discussed in their sequences as applied to the problems that follow. When factors considered for expenditures of munition offer a choice between two conditions, that condition yielding the higher expenditure will be used in computations.

a. Problem 1.

(1) *Given*: A target requires 200 GB 155-mm chemical equivalents to achieve a desired level of casualties.

(2) *Find*: The target requirements in rounds of each of the following munitions: 105-mm shell, 155-mm shell, 8-inch shell, and M55 rockets.

(3) *Solution*: Multiply the appropriate conversion factors in figure 8 by 200. The results are as follows:

Equivalents required	*Munitions*	*Conversion factor*	*Rounds required*
200	105-mm shell	4	800
200	155-mm shell	1. 0	200
200	8-inch shell	. 41	82
200	M55 rocket	. 61	122

b. Problem 1 (continued).

(1) *Given*: Time limit for firing is 30 seconds.

(2) *Find*: The number of 105-mm batteries required; 155-mm batteries; 8-inch batteries; and M91 launcher batteries (M55 rockets).

(3) *Solution:*

(*a*) Using the organization shown in column 5(e) of figure 5 and the rates of fire obtained from figure 9 construct the following table:

Weapon	Rate of fire, 30 sec	Wpn/Btry	Rd/Btry, 30 sec	Rd required from par. 43*a*(3)	No. Btry to give 200 equiv
105-mm how	6	6	36	800	23 (800/36)
155-mm how	3	6	18	200	11
8-inch how	1	4	4	82	21
M91 lchr (M55 rkt)	45	12	540	122	¼ (3-lchr)

(*b*) The figures given in the final column are requirements. Availability of artillery will usually preclude the firing of the mission by tube artillery. In this case the M91 launcher will be the weapon selected for employment.

c. Problem 2.

(1) *Given:*

(*a*) Target size—250 hectares.

(*b*) Target shape—circular.

(*c*) Agent—GB.

(*d*) Delivery means—M91 launcher (M55 rocket).

(*e*) Range from delivery weapon to target—8,000 meters.

(*f*) Target personnel—poorly trained troops with masks available.

(*g*) Casualty level—30 percent; *surprise dosage is desired.*

(*h*) Temperature gradient—inversion.

(*i*) Wind speed—4 knots (approx 7 km/hr).

(*j*) Temperature—50° F. (10° C.).

(*k*) Terrain—open, level, with scattered vegetation.

(*l*) Precipitation—none.

(2) *Find:* The number of M91 rocket launchers required to attack this target.

(3) *Solution:*

(*a*) Using figure 12, determine the total effects components to be 2.29 as follows:

Inversion	0. 67
Wind speed, 7 km/hr	. 50
Temperature, 50° F. (10° C.)	. 12
Open terrain	. 30
No precipitation	. 70
	2. 29

(*b*) Using nomogram, figure 13, place a hairline between 250 on the target area scale, and 30 on the percent casualties for unprotected personnel scale. Obtain a reference point 5.25 on the reference line.

(*c*) Using figure 13, lay the hairline between the reference point 5.25 and 2.29 on the effects components scale; on the munitions expenditure scale, read 480 155-mm equivalents as the required munition expenditure.

(*d*) Using figure 7, read the 155-mm equivalent of the M55 rocket as 1.6. Multiply 1.6 by 45, the total number of rounds in a ripple, and obtain 72 155-mm equivalents for one launcher.

(*e*) Divide the total number of equivalents required, 480, by 72 and obtain a figure of 6.67 or 7 rocket launchers required to fire the mission.

(*f*) As shown in figure 10, the impact pattern of a rocket launcher ripple from an M91 rocket launcher firing at a 8,000-meter range is almost circular. By superimposing the impact patterns of fires from seven launchers on the target area as shown in figure 6, the fires are distributed on the target as evenly as possible. The delivery error has not been considered (par. 41*c*).

d. Problem 3.

(1) *Given:*

(*a*) Target—unprotected personnel.

(*b*) Target size—100 hectares.

(*c*) Target shape—circular.

(*d*) Agent—GB.

(*e*) Weapon—HONEST JOHN, M79 warhead.

(*f*) Wind speed—7 knots (approx 13 km/hr).

(*g*) Temperature gradient—inversion.

(*h*) Temperature—86° F. (30° C.).

(*i*) Terrain—level, with intermittent woods.

(*j*) Precipitation—none.

(2) *Find:* The optimum height of burst and casualty level expected.

(3) *Solution:*

(*a*) From figure 3, FM 3–10A, select the height of burst as 2,000 meters, which gives a coverage of 113 hectares. This will assure coverage of the entire target, not considering delivery error.

(*b*) Using figure 7, find the number of GB 155 chemical equivalents for the M79 warhead to be 60.

(*c*) Using figure 12, determine the total effects components to be 3.02. Effects components are taken from the "GB (over 30-sec attack)" column of the figure since personnel are not protected.

Inversion	1. 09
Wind speed, 13 km/hr	. 70
Temperature, 86° F. (30° C.)	. 23
Open terrain	. 30
No precipitation	. 70
	3. 02

(*d*) Using figure 13, place a hairline between 60 on the munition expenditure scale and 3.02 on the effects components scale and establish a point (5.09) on the reference line.

(*e*) Place the hairline between the reference point, 5.09, and the actual area coverage of the weapon, 113 hectares. Read 43 percent on the percent casualties scale. The size of the bomblet impact pattern is used rather than the actual target size, because the casualty effects pattern is larger than the target and will determine the casualty level within the impact area. If the target area were to be used in this situation, a higher casualty level would be read than actually would occur.

e. Problem 4.

(1) *Given:*

(*a*) Target personnel—poorly trained troops with masks available.

(*b*) Target size—12 hectares.

(*c*) Target shape—rectangular (600 meters wide and 200 meters deep).

(*d*) Agent—GB.
(*e*) Wind speed—5 knots (approx 9 km/hr).
(*f*) Temperature gradient—inversion.
(*g*) Temperature—60° F. (15.5° C.).
(*h*) Terrain—open, level, scattered vegetation.
(*i*) Precipitation—none.
(*j*) Time limitations on the delivery of agent on target—4 minutes or less.
(*k*) Casualty level desired—20 percent.

(2) *Find:* Whether or not the mission can be fired with a 105-mm howitzer battery.

(3) *Solution:*

(*a*) Using figure 11, convert 20 percent casualties among protected personnel to the corresponding casualty level among unprotected personnel. This is 80 percent.

(*b*) Using the "GB (over 30-sec attack)" column of figure 12, determine the total effects components to be 3.21 as follows:

Inversion	1.09
Wind speed, 9 km/hr	1.00
Temperature, 60° F. (15.5° C.)	.12
Open terrain	.30
No precipitation	.70
	3.21

(*c*) Using figure 13, place a hairline between 80 percent on the percent casualties scale and 12 hectares on the target area scale. On the point of intersection on the reference line, pivot the hairline until it intersects 3.21 on the effects components scale. On the munitions expenditure scale, read 12 as the number of 155-mm equivalents required.

(*d*) To find the number of 105-mm rounds required to fire the mission, multiply 12 by a factor of four (obtain this factor from figure 8); the product is 48 rounds.

(*e*) From figure 9, it is evident that one battery of six howitzers can easily fire the mission if no shift of fires is required. Since the target is twice as large as the dispersion pattern of a 105-mm battery (par. 31*c*(3)(*c*) and 41*d*), a shift of fires should be made. Figure 9 gives a time of 30 seconds for shifting of fires. On this basis the battery could fire twenty-four rounds on half the target in a little less than 30 seconds, take 30 seconds to shift fires, and have ample time to deliver the remaining twenty-four rounds on the other half of the target. The firing should be completed in less than 2 minutes.

f. Problem 5.

(1) *Given:*
(*a*) Target size—200 hectares.
(*b*) Target shape—elliptical.
(*c*) Agent—VX.
(*d*) Target personnel—well-trained troops with masks available.
(*e*) Casualty level—30 percent.
(*f*) Temperature gradient—lapse.
(*g*) Temperature—70° F. (21° C.).
(*h*) Wind speed—8 knots (approx 15 km/hr).
(*i*) Terrain—open.
(*j*) Precipitation—none.
(*k*) Firing time limitation—complete fire within 10 minutes.
(*l*) Weapons available—one 8-inch howitzer battery, two 155-mm howitzer batteries, one HONEST JOHN E19R2 warhead.

(2) *Find:* Whether or not the mission can be fired with the weapons available, assuming the target to be within range of the weapons.

(3) *Solution:*

(*a*) Using figure 9, determine the 10-minute rate of fire for the tube artillery weapons concerned. No rate of fire is required for the HONEST JOHN as only one is available. Determine the fire capability of the batteries available. Multiply the total round capability by the appropriate factor in figure 7.

Weapon	Rd, 10 min	Rd/Btry, 10 min	No. of Btry	Total Rd	VX 155-mm equiv, 10 min
155-mm how	30	180	2	360	360
8-inch how	10	40	1	40	87
HONEST JOHN	1	2	½	1	71
Total					518

(*b*) Using figure 12, determine the effects components to be 2.59.

(*c*) Using figure 13, place a hairline between 200 on the target area scale and 30 on the percent casualties scale. Establish a reference point, 5.14, on the reference line. Pivot the hairline on the reference line, placing the hairline on 2.59 on the effects components scale. Read 190 on the munitions expenditure scale.

(*d*) The mission requires 190 155-mm equivalents and 518 equivalents are available; therefore, it can be fired. The required equivalents may be fired by the 155-mm batteries alone or by a combination of weapons, the only limiting factor being the capability of the cannon artillery to traverse to cover the portion of the target assigned.

(*e*) One method of firing the mission would be to assign 70 hectares (fig. 3, FM

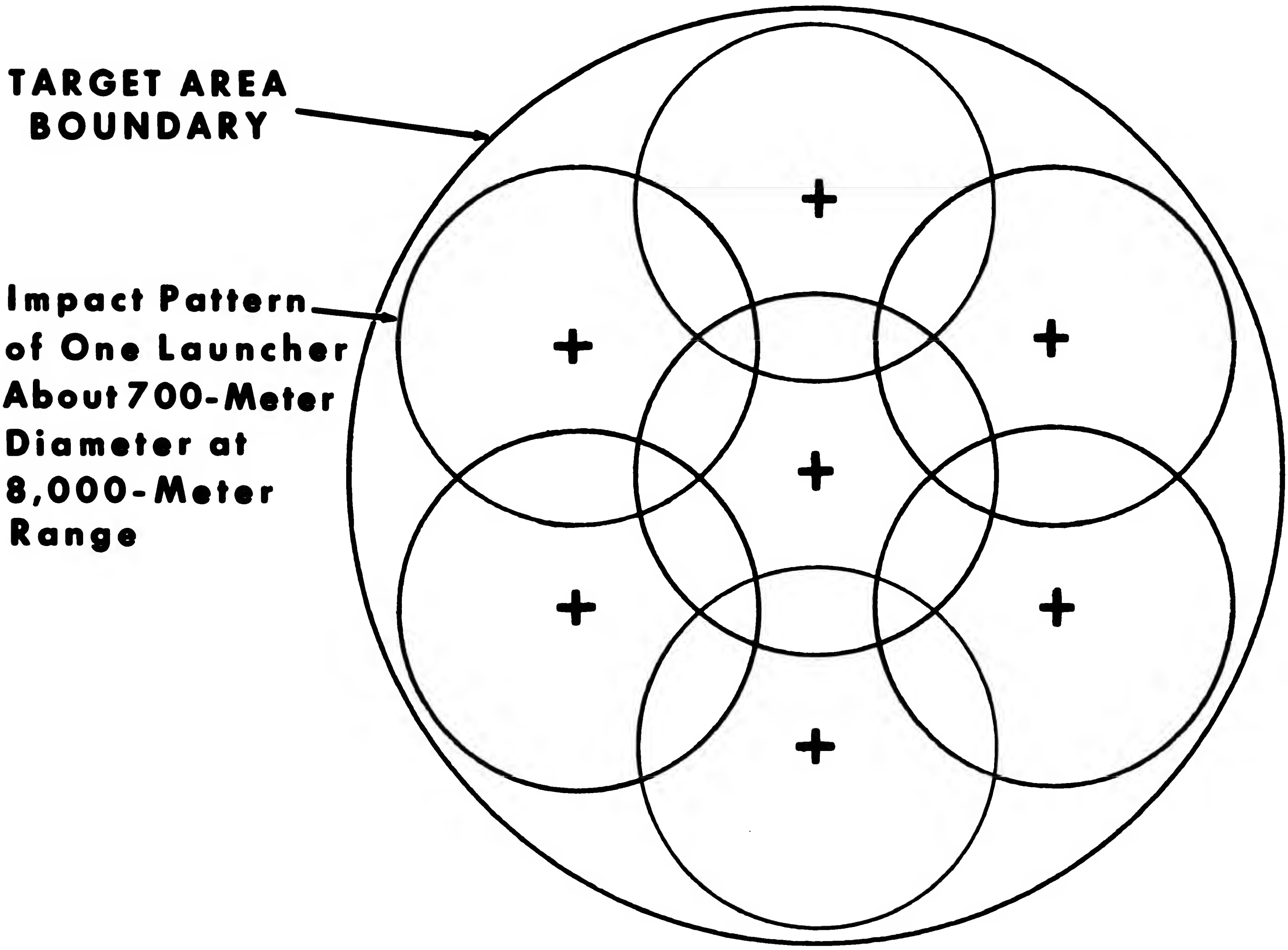


Figure 6. Application of rocket launcher ripple impact patterns to a target. (Seven M91 rocket launcher loads have been fired simultaneously on a 250-hectare target.)

Munition	Munition expressed in terms of 155-mm chemical equivalents		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	0. 25	--------	0. 28
8-inch Shell	2. 40	2. 17	--------
4.2-inch Mortar Shell	--------	--------	. 62
175-mm Shell	2. 1	2. 1	--------
M55 Rocket	1. 6	1. 6	--------
M79 Warhead—HONEST JOHN	60	--------	--------
E19R2 Warhead—HONEST JOHN	71	71	--------
LITTLE JOHN	10	10	--------
SERGEANT	65	65	--------
M34A1 1000-lb Cluster	30	--------	--------
MC1 750-lb Bomb	35	--------	--------
5″/38 Gas Projectile (Navy)	. 50	--------	--------
5″/54 Gas Projectile (Navy)	. 68	--------	--------
5″ Gas Rocket (Navy)	. 74	--------	--------
500-lb Gas Bomb	17	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	6. 2

Figure 7. Munitions expressed in terms of 155-mm chemical equivalents. (The figures given are an estimate of the number of 155-mm howitzer rounds required to give the same effect as one round of the specified munition. Dissemination efficiency has not been considered.)

3–10A; release height, 1,500 meters) to the HONEST JOHN, 50 hectares to each 155-mm battery, and 30 hectares to the 8-inch battery. This will allow the firing to be completed in less than 10 minutes. The HONEST JOHN would fire 71 equivalents, the 155-mm batteries would fire 8 volleys for a total of 96 equivalents, while the 8-inch battery would fire 4 volleys for a total of 35 equivalents. The actual amount of agent fired would be 202 equivalents. In this case cannon artillery will use area fire techniques to distribute the agent evenly on the target.

Munition	Conversion factor		
	GB	VX	HD
155-mm Shell	1	1	1
105-mm Shell	4	--------	3. 6
8-inch Shell	0. 41	0. 45	--------
4.2-inch Mortar Shell	--------	--------	1. 61
175-mm Shell	. 48	. 48	--------
M55 Rocket	. 61	. 61	--------
M79 Warhead—HONEST JOHN	. 017	--------	--------
E19R2 Warhead—HONEST JOHN	. 014	. 014	--------
LITTLE JOHN	. 098	. 098	--------
SERGEANT	. 016	. 016	--------
M34A1 1000-lb Cluster	. 033	--------	--------
MC1 750-lb Bomb	. 029	--------	--------
5″/38 Gas Projectile (Navy)	2. 00	--------	--------
5″/54 Gas Projectile (Navy)	1. 46	--------	--------
5″ Gas Rocket (Navy)	1. 35	--------	--------
500-lb Gas Bomb	. 059	--------	--------
115-lb Gas Bomb (Navy)	--------	--------	. 164

Figure 8. Conversion factors for converting 155-mm munitions to other munitions.

Weapon	Maximum rate (rounds)	Rates of fire for chemical fire missions without shifting or relaying of the piece (rounds)					Estimated time to shift fires
	30 sec	1 min	2 min	4 min	10 min	15 min	
105-mm Howitzer	6	10	14	18	40	60	30 sec
155-mm Howitzer	3	5	7	12	30	40	30 sec
155-mm Gun	2	4	6	8	12	18	60 sec
8-inch Howitzer	1	2	3	6	10	15	60 sec
4.2-inch Mortar	10	16	30 (max)	50	80	105	30 sec
M91 Launcher (M55 Rocket)	45 (15 sec)	Launcher must relocate after firing each ripple.					

Figure 9. Approximate rates of fire for division cannon artillery, mortars, and multiple rockets firing chemical rounds. (Rates of fire for other weapons are given in figure 5.)

DISPERSION PATTERN DATA FOR ONE M91 ROCKET LAUNCHER RIPPLE (45 M55 ROCKETS)—

RANGE (meters)	WIDTH (meters)	DEPTH (meters)	AREA (hectares)	155-mm EQUIVALENTS GB	155-mm EQUIVALENTS VX
4,000	400	1,400	45	72	72
8,000	700	700	40	72	72
10,000	800	600	40	72	72

REPRESENTATION OF THE DISPERSION PATTERN DATA FOR ONE M91 ROCKET LAUNCHER RIPPLE—

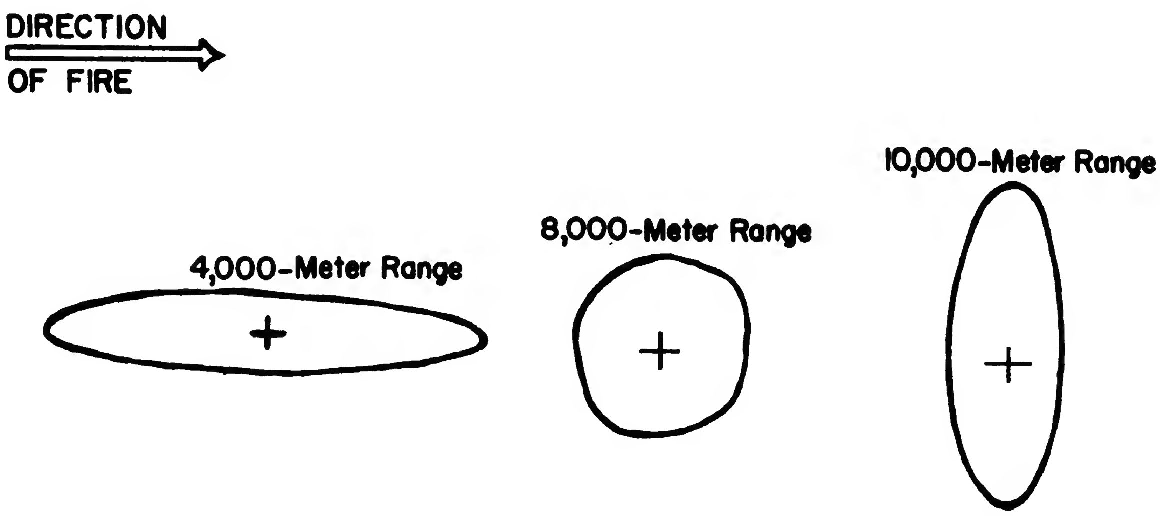
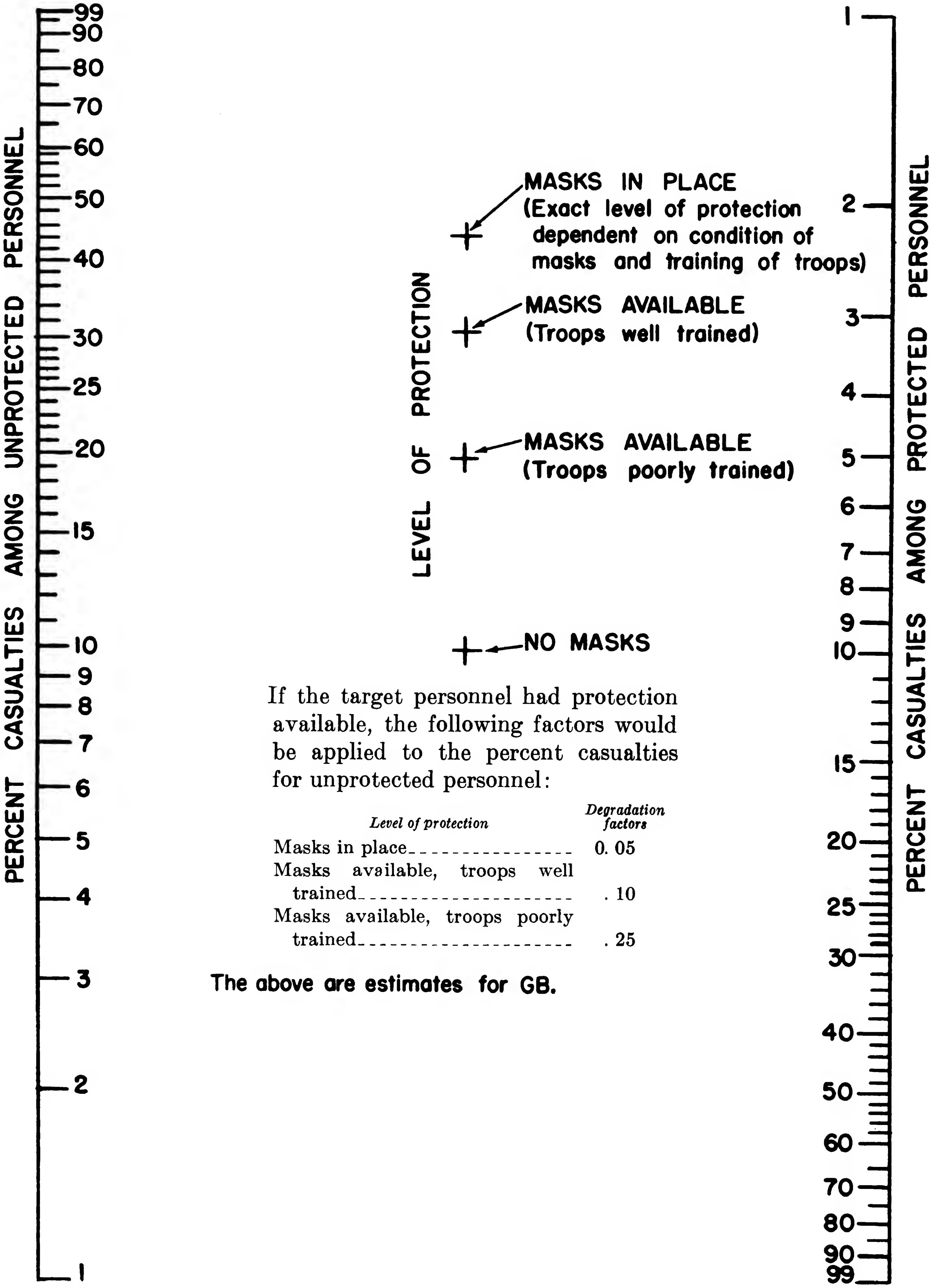


Figure 10. Dispersion patterns of the M91 rocket launcher ripple.



If the target personnel had protection available, the following factors would be applied to the percent casualties for unprotected personnel:

Level of protection	*Degradation factors*
Masks in place	0.05
Masks available, troops well trained	.10
Masks available, troops poorly trained	.25

The above are estimates for GB.

Figure 11. Nomogram for conversion of percent GB casualties for protection of personnel in the target area.

Meteorological and terrain conditions	Effects components			
	GB [2] (surprise attack)	GB (over 30-sec attack)	VX	HD
1. *Temperature Gradient*				
Inversion	0. 67	1. 09	1. 89	0. 69
Neutral	. 57	. 69	1. 89	. 54
Lapse	. 30	. 09	1. 89	. 32
2. *Wind Speed (km/hr)*				
0 to 5	. 20	1. 30	0	. 87
6 to 10	. 50	1. 00	0	. 70
11 to 16	. 70	. 70	0	. 60
17 to 26	. 55	. 30	0	. 48
27 to 52	. 30	0	0	0
3. *Temperature (° F.)*				
a. 0 to 39 (−18° to 4° C.)	0	0	0	----------
40 to 79 (5° to 26° C.)	. 12	. 12	0	----------
80 and up (27° C. and up)	. 23	. 23	0	----------
b. 30 to 49 (−1° to 9° C.)	----------	----------	0	0
50 to 69 (10° to 21° C.)	----------	----------	0	. 70
70 and up (22° C. and up)	----------	----------	0	1. 00
4. *Terrain*				
Open, level, scattered vegetation	. 30	. 30	0	. 30
Rugged, mountainous	0	[1] 0	[1] 0	[1] 0
5. *Precipitation*				
None	. 70	. 70	. 70	0
Moderate rain	0	[1] 0	[1] 0	[1] 0

[1] Estimated.
[2] Tentative figures not yet verified.

Figure 12. Effects components.

Note: paragraph 105 on page 82 states that the "safe entry times" after bio attacks are:

NU (Venezuelan equine encephalitis virus),
AB (bovine brucellosis), and
UL (tularemia): 2 hrs sun or 8 hrs cloudy
OU (Q fever): 2 hrs sun or 18 hrs cloudy

Cloudy conditions also apply to nighttime

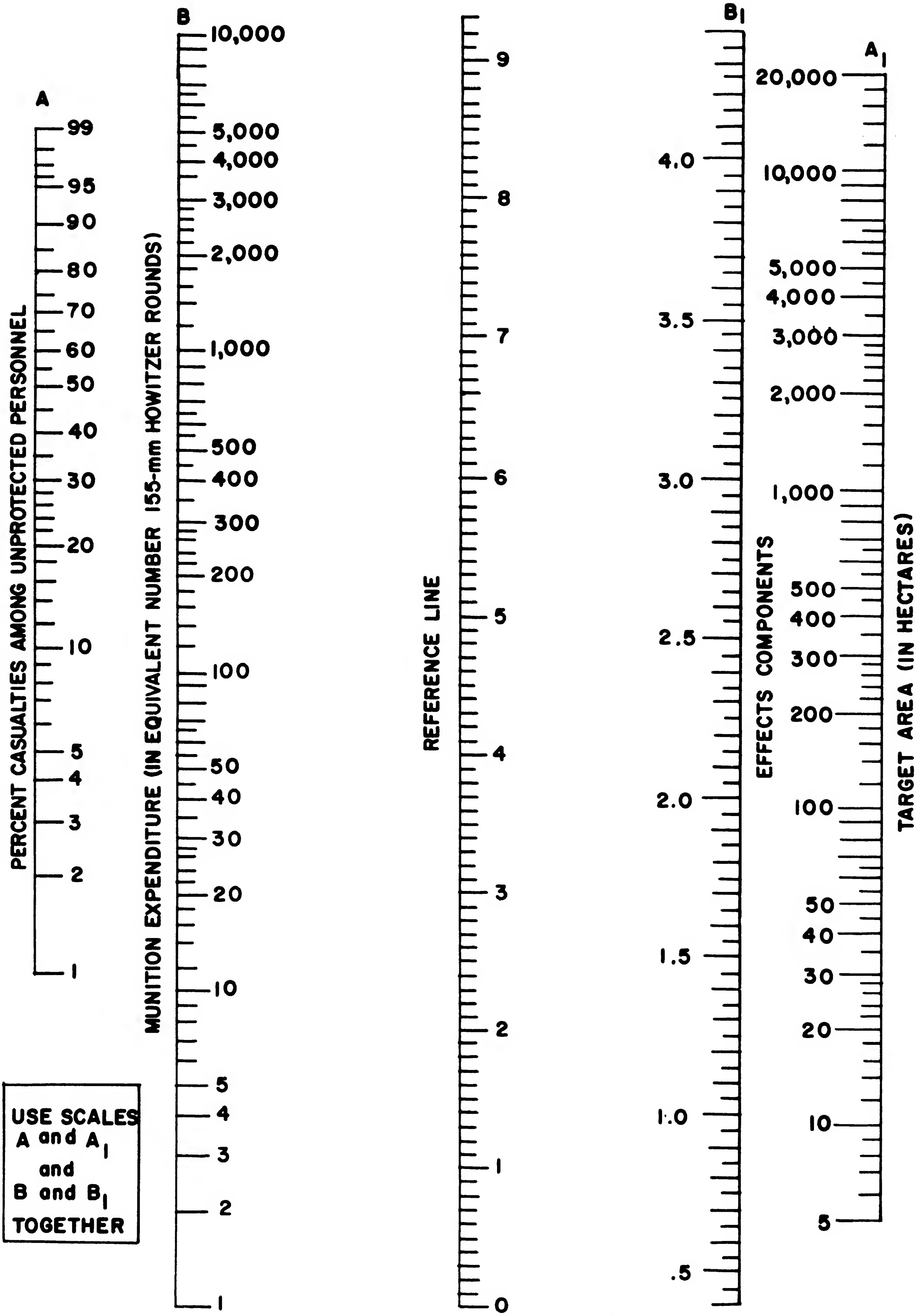


Figure 13. Target area, casualty level, munitions requirement nomogram.

Section II. TROOP SAFETY CALCULATIONS

52. General

This section provides commanders and staff officers with procedures for:

a. Determining the minimum safe distance for friendly troop dispositions close to the target area.

b. Determining the time after the chemical attack at which unprotected friendly troops can enter or cross areas at specified distances downwind of the target area.

c. Forecasting the area to be affected by hazardous vapor dosages.

d. Alerting friendly units concerned.

53. Minimum Safe Distance

To determine the minimum safe distance (MSD) from the center of impact for friendly troops located close to the target area, the following formula is used:

$$MSD = \tfrac{1}{2}D + d_b,$$

where D is the maximum diameter of the impact area, and d_b is the buffer distance. For a very high assurance of troop safety, d_b is computed as follows:

a. For missiles and air-delivered weapons, the d_b is 2 CEP (circular error probable). The CEP for these weapons will be obtained from the delivery unit or appropriate firing table.

b. For tube artillery and rockets, the probable error will be obtained from the delivery unit. The d_b for these weapons is 3.5 times the largest error plus 200 meters.

54. Safe Entry Time Into an Area Downwind of the Target Area

a. In considering the safe entry time for unmasked personnel into an area downwind of the target (when the entry area is within the downwind hazardous distance), the time of cloud arrival to the entry area and time of cloud clearance of the entry area must be determined. In computing these times, the following factors must be considered:

(1) The time the chemical fire mission is completed.

(2) The chemical agent cloud measurement parallel to the wind direction.

(3) Wind speed and direction.

(4) Drag effects (the retarding action on the movement of the agent cloud caused by irregularities of terrain, slight changes in wind speed and direction, presence of vegetation, and other factors).

b. The calculated time for chemical cloud clearance of the entry area is based on the time the firing is completed and the time it will take the tail of the cloud to travel the downwind distance to clear the entry area. Since drag effects cannot be precisely measured, a safety factor of 10 minutes is added to time scheduled for cloud clearance of the entry area.

55. Computation of Maximum Downwind Distance

a. Nomogram Method.

(1) The maximum downwind distance (MDD) to which a given dosage may extend is computed by the use of nomograms (figs. 14 and 15). The wind speed in kilometers per hour, the dosage is milligram-minutes per cubic meter, the source length in kilometers, the source strength in kilograms per meter, and the temperature gradient must be known in order for the nomograms to be used. The forecast of meteorological data is obtained from the intelligence staff section. The dosage used will be determined by the degree of risk as prescribed or implied by the commander. Normally, the negligible risk dosage (par. 51*a*) will be used. The source length is the length in kilometers of the crosswind axis of the impact area. The effective source strength is equal to the total weight in kilograms of agent delivered on target, divided by the source length in meters. The total weight in kilograms of agent delivered on the target is computed by multiplying the number of munitions delivered on target by the weight of agent per munition in kilograms as given in figure 5.

(2) Example problem for computation of maximum downwind distance.

(*a*) *Given:* Target area—40 hectares, rectangular in shape, approximately 800 x 500 meters.

Wind speed—7.5 knots (approx 14 km/hr).

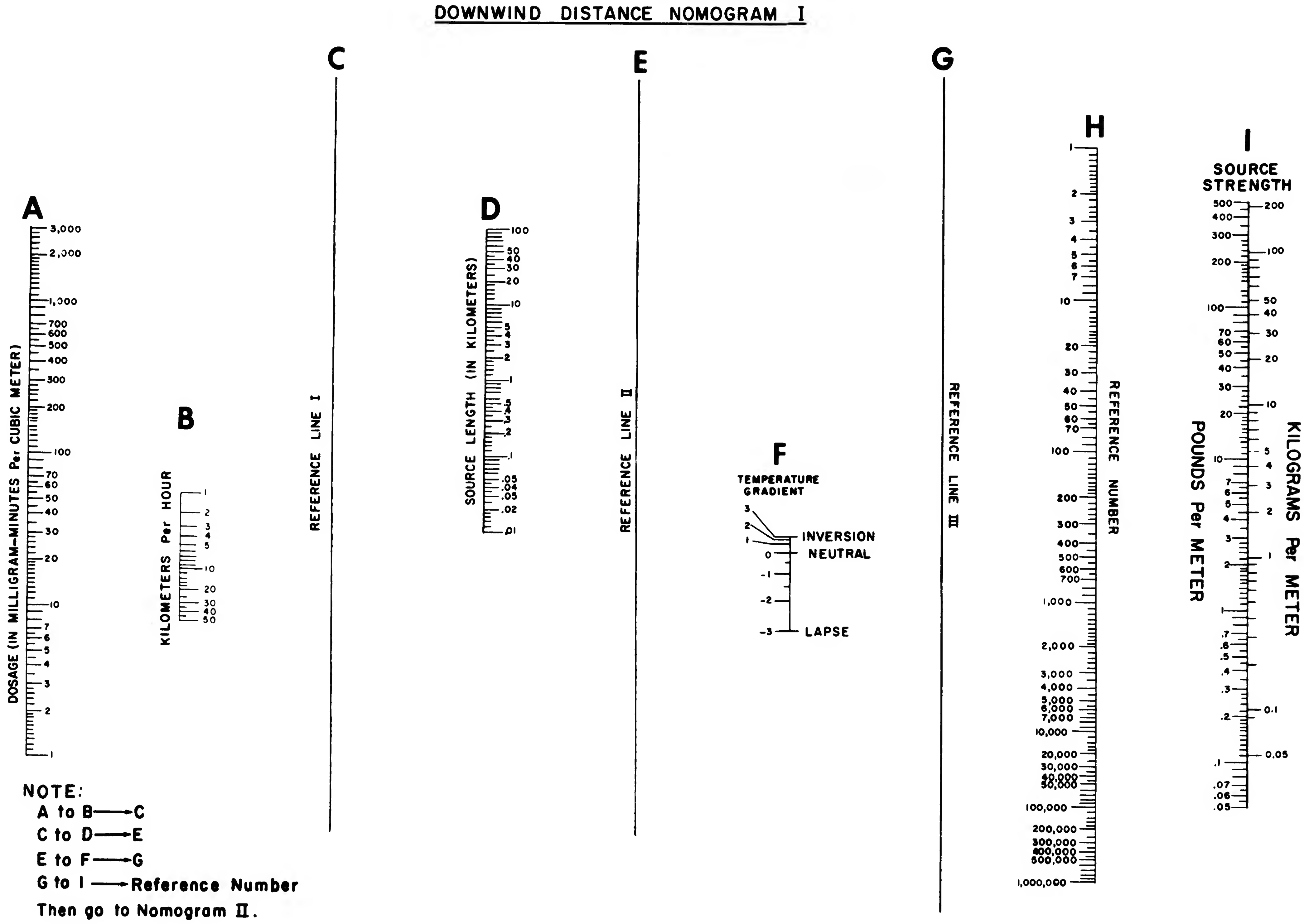


Figure 14. Downwind distance nomogram I.

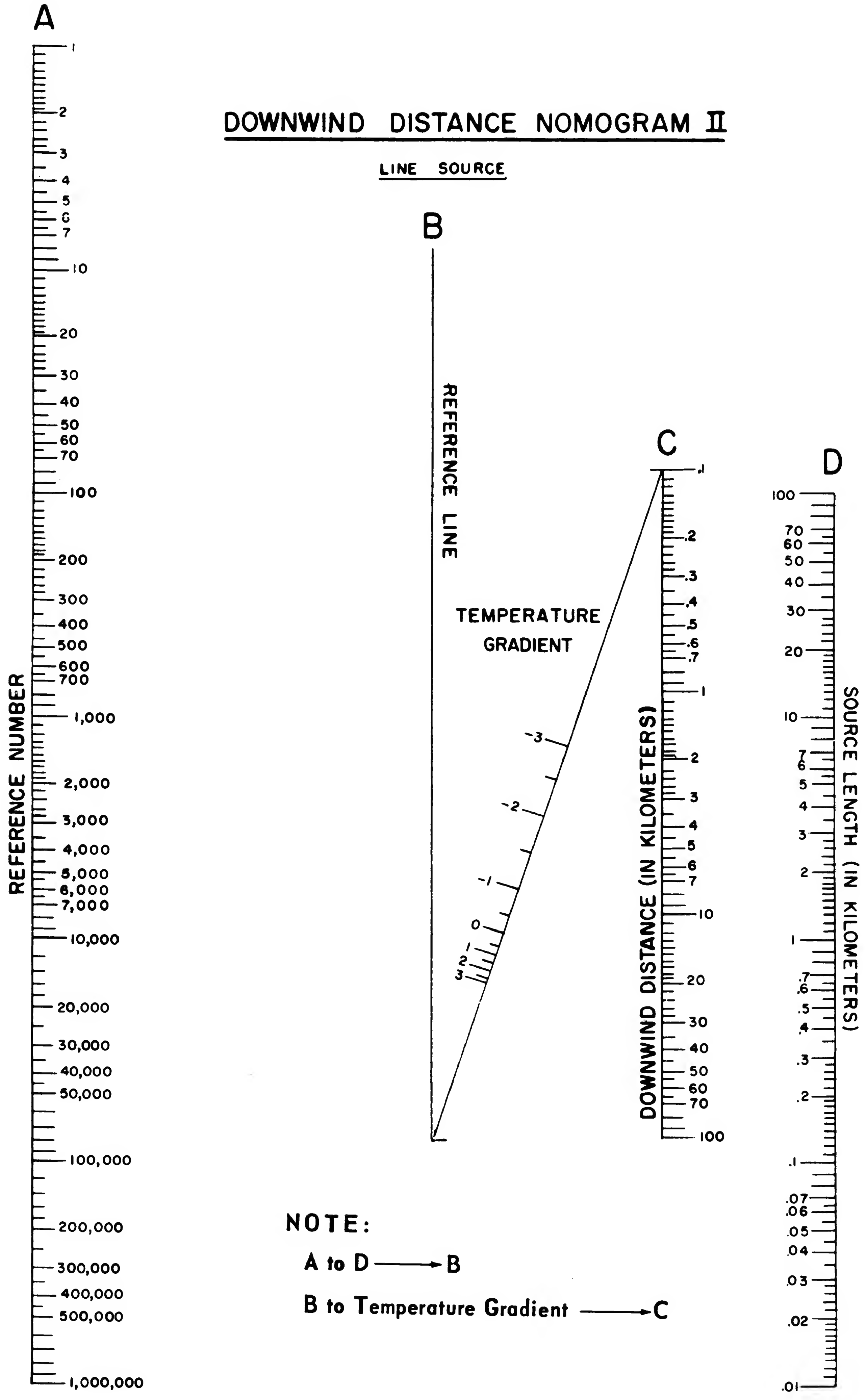


Figure 15. Downwind distance nomogram II.

Wind direction—perpendicular to the 800-meter axis of the target.

Source length—800 meters (.8 km).

Agent and munition to be used—GB, 68 155-mm rounds.

Temperature gradient—0 (neutral).

(*b*) *Find:* Maximum downwind distance to which a vapor cloud of 5 mg-min/m^3 dosage will extend.

(*c*) *Solution:*

1. Using the downwind distance nomogram I (fig. 14), connect with a hairline 5 mg-min/m^3 on the dosage scale with 14 km/hr on the wind speed scale. Note the point of intersection on reference line I.

2. Pivot the hairline on the point of intersection on reference line I and connect with .8 km on the source length scale. Note the point of intersection on reference line II.

3. Pivot the hairline on the point of intersection on reference line II and connect with 0 (neutral) on the temperature gradient scale. Note the point of intersection on reference line III.

4. Determine the effective source strength of the agent by the following formula:

$$\text{Effective source strength} = \frac{\text{No. of rounds} \times \text{kg of agent/round}}{\text{Source length (length in meters of the crosswind axis of target)}}$$

$$= \frac{68 \times 2.95}{800}$$

Effective source strength=0.25 kg/m.

5. Connect with the hairline the point of intersection on reference line III with 0.25 kg/m on the source strength scale. This line intersects the reference number scale at 17,000.

6. Turn to downwind distance nomogram II, figure 15. Connect with the hairline the value of 17,000 on the reference number scale with .8 km on the source length scale. Note the point of intersection on the reference line.

7. Pivot the hairline on the point of intersection on the reference line and connect with 0 on the temperature gradient scale. Read a value of 4.5 kilometers on the downwind distance scale.

(*d*) Answer: 4.5 kilometers is the maximum downwind distance to which a vapor cloud of 5 mg-min/m^3 dosage will extend under the given conditions.

b. Slide Rule Method.

(1) A slide rule for calculation of downwind distance for a given set of conditions is in the back cover.

(2) The slide rule requires the same input data as is used in the nomogram method and its operation is illustrated in the problem that follows.

(3) Compute the downwind distance to a dosage level of 5 mg-min/m^3 given the following conditions:

Length of source	800 meters
Source strength	.25 kg/m
Wind speed	7.5 knots (approx 14 km/hr)
Temperature gradient	neutral (0)

(*a*) Aline 5 mg-min/m^3 on the D scale with 800 meters on the L scale.

(*b*) Allowing the center wheel to turn with the middle wheel so that the two wheels remain fixed in position with respect to each other, aline .25 kg/m on the P scale with 14 km/hr on the U scale.

(*c*) Read 10.3 on scale M opposite the neutral (0) point on the temperature gradient (ΔTG) scale.

(*d*) On the reverse side of the slide rule, aline 800 meters on scale L with 10.3 on the M scale.

(*e*) Holding the alinement, read about 4.6 kilometers where the downwind distance scale is intersected by the neutral (0) curve.

REFERENCE BOOK

CHEMICAL AND BIOLOGICAL WEAPON EMPLOYMENT

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE
Fort Leavenworth, Kansas
1 May 1968

This reference book supersedes RB 3-1, 1 May 1967

CHAPTER 2
TOXIC CHEMICAL AGENTS

1. Characteristics and Effects

a. General. The following antipersonnel chemical agents are used for College instruction in chemical weapon employment: nerve agents GB and VX; blister agent HD (mustard); and incapacitating agent BZ. Actual or assumed characteristics of these agents are described in the following paragraphs for instructional purposes only and are summarized in figure 1.

b. Nerve Agent GB. GB is a quick acting, nonpersistent lethal agent that produces casualties primarily by inhalation.

(1) Inhalation effects. Inhaled GB vapor can produce casualties within minutes. As an example, 50 percent of a group of unprotected troops engaged in mild activity, breathing at the rate of about 15 liters per minute, and exposed to 70 milligrams of GB per cubic meter of air for 1 minute will probably die if they do not receive medical treatment in time. This is the median lethal dosage (50) and is expressed as 70 mg-min/m^3. For troops engaged in activities that increase their breathing rate, the median lethal dosage can be as low as 20 mg-min/m^3. The median incapacitating dosage of GB vapor by inhalation is about 35 mg-min/m^3 for troops engaged in mild activity. Incapacitating effects consist of nausea, vomiting, diarrhea, and difficulty with vision, followed by muscular twitching, convulsions, and partial paralysis. Dosages of GB less than the median incapacitating dosage cause general lowering of efficiency, slower reactions, mental confusion, irritability, severe headache, lack of coordination, and dimness of vision due to pinpointing of the eye pupils.

(2) Percutaneous effects. Percutaneous effects refer to those effects produced by the absorption of the agent through the skin. GB vapor absorbed through the skin can produce incapacitating effects. Sufficient GB liquid absorbed through the skin can produce incapacitation or death. The effectiveness of the liquid or vapor depends on the amount absorbed by the body. Absorption varies with the original amount of agent contamination, the skin area exposed and the exposure time, the amount and kind of clothing worn, and the rapidity in removing the contamination and/or contaminated clothing and in decontaminating affected areas of the skin.

(3) Major considerations in the employment of nerve agent GB. The employment of GB is based primarily on achieving casualties by inhalation of the nonpersistent vapor (or aerosol) of the agent. Major considerations in the employment of this agent are:

(a) Time to incapacitate. The onset of incapacitation resulting from inhalation of casualty-producing doses is rapid, the average time being approximately 3 minutes. To allow for the time required for the agent cloud to reach the individual, 10 minutes is used as the mean time to achieve incapacitation. Nonlethal casualties from GB will be incapacitated for 1 to 5 days.

(b) Persistency. Persistency is defined as the length of time an agent remains effective in the target area after dissemination. Nerve agent GB is considered nonpersistent. GB clouds capable of producing significant casualties will dissipate within minutes after dissemination. Some liquid GB will remain in chemical shell or bomb craters for periods of time varying from hours to days, depending on the weather conditions and type of munition. Because of this continuing but not readily discernible threat, GB can also be highly effective in harassing roles by causing exposure to low concentrations of the vapor. Rounds fired sporadically may compel the enemy to wear protective masks and clothing for prolonged periods, thereby impairing his effectiveness as a result of fatigue, heat stress, discomfort, and decrease in perception.

(c) Level of protection. The weapon system requirements for positive neutralization of masked personnel by GB are too great to be supported except for important point or small area targets. A major factor affecting casualties resulting from GB attacks of personnel equipped with masks but unmasked at the time of attack is the time required for enemy troops to mask after first detecting a chemical attack. Therefore, surprise dosage attack is used to establish a dosage sufficient to produce the desired casualties before troops can mask. Casualty levels for surprise dosage attack that are tabulated in the weapon system effects tables (app A) are based on an assumed enemy masking time of 30 seconds. (Refer to FM 3-10 series manuals for operational data for masking times less than 30 seconds.) A total dosage attack is used to build up the dosage over an extended period of time and is normally employed against troops who have no protective masks available. Dosages built up before troops can mask inside foxholes, bunkers, tanks, buildings, and similar structures will generally be less than dosages attained during the same period of time in the open, thereby reducing the effects on occupants from surprise dosage attacks. Total dosage effects are essentially the same inside or outside.

c. Nerve Agent VX. VX is a slow-acting, lethal, persistent agent that produces casualties primarily by absorption of droplets through the skin.

(1) Effects. VX acts on the nerve systems of man; interferes with breathing; and causes convulsions, paralysis, and death.

(2) Major considerations in the employment of nerve agent VX.

(a) General. Agent VX disseminated in droplet (liquid) form provides maximum duration of effectiveness as a lethal casualty threat. VX will remain effective in the target area for several days to a week depending on weather conditions. Because of its low volatility, there is no significant vapor hazard downwind of a contaminated area. Except when disseminated by aircraft spray tanks, meteorological conditions have little effect on the employment of VX, although strong winds may influence the distribution of the agent and heavy rainfall may wash it away or dissipate it.

(b) Employment to cause casualties. Agent VX is appropriate for direct attack of area targets containing masked personnel in the open or in foxholes without overhead protection, for causing severe harassment by the continuing casualty threat of agent droplets on the ground or on equipment, and for creating obstacles to traversing or occupying areas. Casualties produced by agent VX are delayed, occurring at times greater than 1 hour after exposure. Although this agent can be used relatively close to friendly forces, it should not be used on positions that are likely to be occupied by friendly forces within a few days. Because of this continuing hazard, areas in which agent VX has been used should be recorded in a manner similar to minefields or fallout areas so that necessary precautions can be taken.

d. Blister Agent HD. HD, sometimes referred to as mustard, is a persistent slow-acting agent that produces casualties through both its vapor and liquid effects.

(1) Vapor effects.

(a) The initial disabling effect of HD vapor on unmasked troops will be injuries to the eyes. Temporary blindness can be caused by vapor dosages that are insufficient to produce respiratory damage or skin burns. However, skin burns account for most injuries to masked troops. The vapor dosages and the time required to produce casualties (4 to 24 hours) vary with the atmospheric conditions of temperature and humidity and with the amount of moisture on the skin. Depending on their severity, skin burns can limit or entirely prevent movement of the limbs or of the entire body.

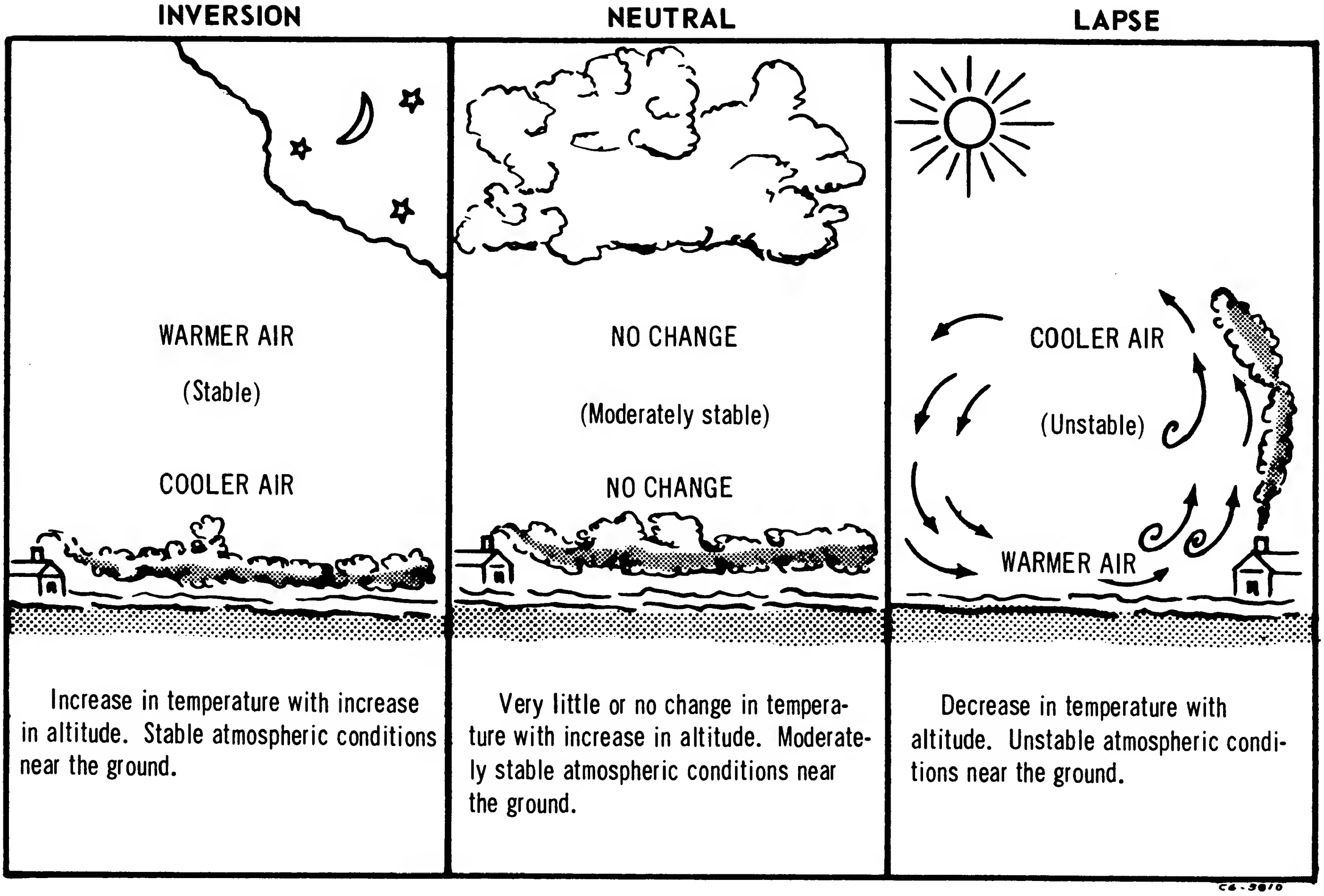


Figure 2. Temperature gradients.

Surprise dosage GB attacks are influenced only slightly by the temperature gradient except when made with the spray tank. Downwind vapor hazards to both enemy and friendly forces will be most significant during inversion and neutral conditions. Employment of VX is not affected by the temperature gradient.

Temperature gradients	Time
1. Inversion	From sunset to sunrise.
2. Neutral	2 hours before sunset to sunset, sunrise to 2 hours after sunrise, or any time windspeed is 15 kmph or greater.
3. Lapse	2 hours after sunrise to 2 hours before sunset.

Figure 3. Estimated times that temperature gradients will prevail. (Use when meteorological data are not available.)

(3) When actual or predicted meteorological conditions are not available for a target analysis, 70° F is used for temperature, 9 kmph is used as windspeed, and the temperature gradient is approximated from figure 3.

d. Windspeed and Direction.

(1) Air moving over the earth's surface sets up eddies, or mechanical turbulences, that act to dissipate a chemical cloud. A condition of calm will limit the merging of the individual gas clouds. Both of these conditions may reduce the effectiveness of a chemical agent attack. High winds increase the rate of evaporation of HD and dissipate chemical clouds more rapidly than low winds. Moderate winds are desirable for chemical employment. Large-area nonpersistent chemical attacks are most effective in winds not exceeding 28 kmph. Small-area nonpersistent chemical attacks with rockets or shell are most effective in winds not exceeding 9 kmph. However, if the concentration of chemical agent can be established quickly, the effects of high windspeed can be partially offset.

CHAPTER 4
EMPLOYMENT OF BIOLOGICAL AGENTS

1. General

a. Antipersonnel biological agents are micro-organisms that produce disease in man. These agents can be used to incapacitate or kill enemy troops through disease. They may cause large numbers of casualties over vast areas and could require the enemy to use many personnel and great quantities of supplies and equipment to treat and handle the casualties. Many square kilometers can be effectively covered from a single aircraft or missile. The search capability of biological agent clouds and the relatively small dose required to cause infection among troops give biological munitions the capability of covering large areas where targets are not precisely located.

b. A biological attack can occur without warning since biological agents can be disseminated by relatively unobtrusive weapon systems functioning at a considerable distance from the target area and relying upon air movement to carry the agent to the target.

c. Biological agents do not produce effects immediately. An incubation period is required from the time the agent enters the body until it produces disease. Some agents produce the desired casualty levels within a few days, whereas others may require more time to produce useful casualty levels. A variety of effects may be produced, varying from incapacitation with few deaths to a high percentage of deaths, depending on the type of agent.

2. Methods of Dissemination

a. The basic method of disseminating antipersonnel biological agents is the generation of aerosols by explosive bomblets and spray devices. Because exposure to sunlight increases the rate at which most biological agent aerosols die and thereby reduces their area coverage, night is the preferable time for most biological attacks. However, if troop safety is a problem, an attack may be made near sunrise to reduce the distance downwind that a hazard to friendly forces will extend. Conversely, to extend the downwind cloud travel and the area coverage from spray attack, a biological agent may be employed soon after sundown.

b. Missile-delivered Biological Munitions. Missile-delivered biological munitions are used for attack of large-area targets. A typical biological missile system consists of the following components:

(1) A missile vehicle and its launching equipment.

(2) A warhead that can be opened at a predetermined height to release biological bomblets over the target area. The warhead is shipped separately for assembly to a missile at the launching site.

(3) A warhead shipping container equipped with a heating-cooling element and a temperature control unit.

(4) Biological bomblets consisting of an agent container and a central burster that functions on impact. The bomblets have vanes that cause them to rotate in flight, thereby achieving lateral dispersion during their free fall and resulting in random distribution as a circular pattern.

c. Aircraft Spray Tank. Biological agents released from an aircraft spray tank cover a large area downwind of the line of release. A typical spray tank consists of the following components:

(1) An agent reservoir section that is shipped separately in an insulated shipping and storage container equipped with a heating-cooling element and a temperature control unit.

(2) A discharge nozzle assembly that can be mechanically adjusted to vary the agent flow rate.

Table 1. Chemical Weapons Data

1	2	3	4	5	6	7	8	9	10	11	12	13
Delivery system	Range (meters)		Agent	Munition	No of weapons per delivery unit	Weapon rate of fire	RT max (meters)[1 2]					Reference (table)
							Fire unit	Total dosage		Surprise dosage		
								Casualty threat		Casualty threat		
	Min	Max						10%	30%	10%	30%	
4.2-in mortar	180	4,500	HD	Cartridge, M2A1	4/Plat	50 rd/3 min 105 rd/15 min						18 19
105-mm howitzer		11,100	GB	Cartridge, M360	6/btry	5 rd/30 sec 30 rd/3 min 66 rd/15 min	1 btry[3]	200	100	100	50	2
							1 bn[3]	300	300	200	100	3
			HD	Cartridge, M60								18 19
155-mm howitzer		14,600	GB	Projectile, M121	6/btry	2 rd/30 sec 12 rd/3 min 24 rd/15 min	1 btry[3]	300	200	100	0	4
							1 bn[3]	500	400	300	100	5
			HD	Projectile, M110								18 19
			VX[4]	Projectile, M121			1 btry[3]	400	200	NA	NA	13
							1 bn[3]	500	400			
8-in howitzer		16,800	GB	Projectile, M426	4/btry	1 rd/30 sec 4 rd/3 min 10 rd/15 min	1 btry[3]	300	200	200	0	6
							1 bn[3]	500	400	300	100	7
			VX[4]				1 btry[3]	400	200	NA	NA	14
							1 bn[3]	500	400			
115-mm multiple rocket launcher, M91	2,740	10,600	GB[4]	Rocket, M55 (THE BOLT)		45 rkt/lchr/15 sec	1 lchr	1,000	750	500	200	8
							3 lchr	1,000	1,000	750	400	
							6 lchr	1,000	1,000	1,000	750	
							9 lchr	1,000	1,000	1,000	1,000	
			VX[4]				1 lchr	300	0	NA	NA	15
							3 lchr	750	300			
							6 lchr	1,000	400			
							9 lchr	1,000	750			
762-mm rocket, Honest John	8,500	38,000	GB[4]	Warhead, M190 (M139 bomblets)	2/btry	2 rkt/lchr/hr	1 lchr	600	600	600	400	9
							2 lchr	600	600	600	400	
Sergeant missile	46,000	139,000	GB[4]	Warhead, M212 (M139 bomblets)	2/bn	2 msl/lchr/hr	1 msl	600	400	600	200	10
							2 msl	600	600	600	400	
Aircraft	Dependent on type aircraft		GB[4]	Bomb, MC-1, 750-lb		Dependent on type aircraft	1 bomb	50				11
							6 bombs	300	200	300	50	
							12 bombs	500	300	400	200	
							24 bombs	500	300	500	300	
			GB[4]	Spray tank, 100-gal			1 spray tank	RT max=750 meters (one-half effective spray release line length)				12
							2 spray tanks					
			VX[4]				1 spray tank	RT max=500 meters (one-half effective spray release line length)				16
			BZ[4]	Bomb, 150-lb								17
				Bomb, 700-lb								

[1]RT max is largest target radius for which indicated casualty threat is tabulated for appropriate fire unit. Division of target into subtargets NOT considered.

[2]All windspeeds, temperature gradients, and protection categories considered.

[3]RT max computed for maximum number of volleys for which data are tabulated.

[4]Weapon system capabilities derived from tables composed of hypothetical data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 2. Estimated Fractional Casualty Threat From 105-mm Howitzer, GB Projectile, Battery Fire[1,2]

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Target radius–radius of effect (meters)	Range to target (km)	No of volleys	Windspeed[3]											
			4 kmph				9 kmph				28 kmph			
			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]			Surprise[4]	Total dose[5]		
				I	N	L		I	N	L		I	N	L
50	<7.5	1	.10	.25	.20	.15	.10	.15	.10	.10				
		2	.20	.45	.40	.30	.15	.30	.25	.20		.10	.05	.05
		3	.30	.60	.60	.35	.30	.50	.45	.30	.10	.20	.15	.10
		4	.30	.75	.70	.45	.30	.55	.45	.35	.10	.25	.20	.10
		5	.35	.90	.85	.55	.35	.60	.50	.40	.15	.30	.25	.15
	>7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.15	.30	.25	.15	.10	.20	.15	.10		.05	.05	
		3	.15	.30	.30	.25	.10	.20	.20	.15		.10	.05	.05
		4	.20	.40	.35	.25	.15	.30	.30	.15	.05	.15	.15	.05
		5	.25	.45	.45	.30	.25	.40	.35	.25	.10	.20	.20	.10
100	<7.5	1	.05	.15	.15	.10	.05	.10	.05	.05				
		2	.10	.30	.30	.15	.10	.20	.15	.10				
		3	.15	.40	.35	.20	.15	.25	.25	.15	.05	.10	.05	
		4	.15	.40	.35	.30	.15	.30	.30	.15	.05	.10	.10	.05
		5	.20	.45	.40	.35	.20	.35	.35	.20	.10	.15	.15	.10
	≥7.5	1	.05	.10	.10	.05		.05	.05					
		2	.10	.20	.20	.10	.05	.15	.10	.05				
		3	.10	.25	.25	.15	.10	.15	.15	.10		.05	.05	
		4	.10	.30	.25	.20	.10	.25	.20	.15		.10	.05	
		5	.15	.35	.30	.25	.15	.30	.25	.15	.05	.15	.10	.05
200	Any	1		.05	.05									
		2		.10	.10	.05		.05	.05					
		3	.05	.15	.15	.05		.10	.05					
		4	.05	.15	.15	.10		.10	.10					
		5	.05	.20	.20	.10	.05	.15	.10	.05				

[1]Blank spaces indicate fractional casualties are below 0.05.

[2]If the target is predominately wooded, use a windspeed of 4 kmph and neutral temperature gradient for total dose attack; use a windspeed of 4 kmph for surprise attack.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

[4]Multiply the figures given in the table by the appropriate factor to obtain the fractional casualties from surprise dose attack:

Troops in open foxholes:	0.7
Troops in covered foxholes or bunkers:	0.6

[5]I=inversion, N=neutral, L=lapse.

Table 17. BZ Munitions Requirements

1	2	3	4	5	6
Munition	Casualty level[2]	Area coverage[1] (square kilometers)			
		Windspeed[3]			
		8 kmph		16 kmph	
		Temperature gradient		Temperature gradient	
		Inversion	Neutral	Inversion	Neutral
150-lb bomb	.40	.05	.02	.03	.01
	.75	.03	.01	.02	.009
700-lb bomb	.40	.20	.07	.09	.04
	.75	.10	.04	.05	.03

[1]Area coverages are for one bomb.

[2]Casualty levels are for personnel without masks available. For personnel with masks available, multiply casualty levels by 0.7.

[3]For windspeeds other than those shown, use data given for the nearest windspeed.

NOTE: The above table is composed of hypothetical munitions and data for INSTRUCTIONAL PURPOSES ONLY at the U. S. Army Command and General Staff College. For actual data, refer to FM 3-10.

Table 18. HD Ammunition Expenditure for Vapor Effect (50 Percent Coverage of Target Area)[1] [2]

Rounds required per hectare — 4.2-inch mortar (cartridge M2A1)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed 6 kmph, I	6, N	6, L	9, I	9, N	9, L	15, I	15, N	15, L	26, I	26, N	26, L
Cause eye irritation to troops without masks.	1	½	¼	⅛	10	14	16	11	21	22	15	22	26	20	24	29
	2	1	½	¼	6	8	9	8	12	14	12	13	16	17	21	24
	4	2	1	½	6	6	8	8	9	10	9	10	13	13	16	20
	8	4	2	1	4	6	6	6	8	9	8	9	11	12	13	15
	16	8	4	2	4	5	5	5	8	9	8	8	10	10	11	13
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	35	46	52	39	53	63	46	63	80	59	77	108
	2	1	½	¼	20	29	33	24	35	40	30	45	56	41	59	69
	4	2	1	½	15	21	24	17	27	33	24	35	42	30	47	65
	8	4	2	1	11	17	18	13	21	26	17	28	38	27	45	63
	16	8	4	2	9	14	16	11	18	22	16	24	33	24	42	58
Disable masked troops (dry weather).	1	½	¼	⅛	64	83	95	72	95	114	86	113	144	108	144	198
	2	1	½	¼	36	52	58	44	62	72	57	81	101	71	120	125
	4	2	1	½	26	35	41	30	46	56	45	62	76	57	86	119
	8	4	2	1	18	27	30	23	35	44	32	50	68	50	81	114
	16	8	4	2	13	21	26	18	30	40	29	46	60	42	72	108

Rounds required per hectare — 105-mm howitzer (cartridge M60)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed 6 kmph, I	6, N	6, L	9, I	9, N	9, L	15, I	15, N	15, L	26, I	26, N	26, L
Cause eye irritation to troops without masks.	1	½	¼	⅛	22	24	27	24	34	39	39	44	46	32	53	65
	2	1	½	¼	18	22	23	20	22	27	29	32	34	26	39	51
	4	2	1	½	16	17	20	17	18	20	20	22	24	22	29	39
	8	4	2	1	12	15	17	13	12	17	15	20	22	18	27	36
	16	8	4	2	10	12	13	10	11	15	12	17	20	15	24	34
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	70	83	108	77	95	121	95	123	166	108	157	243
	2	1	½	¼	42	54	63	47	63	84	66	89	102	82	108	192
	4	2	1	½	27	36	45	32	47	62	48	64	84	64	88	162
	8	4	2	1	18	29	34	24	38	47	33	53	76	54	83	138
	16	8	4	2	15	23	27	18	32	42	30	51	66	48	72	120
Disable masked troops (dry weather).	1	½	¼	⅛	128	154	174	144	174	212	189	...	...	202	...	...
	2	1	½	¼	75	98	128	89	113	147	111	156	180	148	198	288
	4	2	1	½	50	64	81	59	86	111	88	118	153	117	165	256
	8	4	2	1	33	50	58	45	65	84	62	95	138	101	154	240
	16	8	4	2	26	39	45	34	56	72	54	84	120	84	132	193

Rounds required per hectare — 155-mm howitzer and gun (projectiles M110 and M104)

Desired effect[3]	Exposure time (hours), Temperature (°F) 55°	70°	85°	100°	Windspeed 6 kmph, I	6, N	6, L	9, I	9, N	9, L	15, I	15, N	15, L	26, I	26, N	26, L
Cause eye irritation to troops without masks.	1	½	¼	⅛	8	10	10	9	11	12	10	12	13	11	14	16
	2	1	½	¼	6	8	9	8	10	11	9	11	12	10	12	14
	4	2	1	½	4	5	6	6	8	9	8	9	10	9	10	12
	8	4	2	1	4	5	5	5	6	8	6	8	9	8	9	11
	16	8	4	2	4	4	4	4	5	6	5	6	8	5	8	10
Disable masked troops (sweating in humid weather).	1	½	¼	⅛	20	28	30	23	32	36	26	39	44	32	46	58
	2	1	½	¼	12	17	20	15	22	24	18	27	34	24	36	46
	4	2	1	½	10	13	16	11	18	20	15	20	27	18	29	33
	8	4	2	1	6	10	12	9	13	16	12	17	24	16	23	33
	16	8	4	2	5	9	11	8	11	15	11	15	22	15	20	29
Disable masked troops (dry weather).	1	½	¼	⅛	36	48	53	41	56	63	46	66	78	59	83	105
	2	1	½	¼	21	28	33	26	36	41	38	54	63	42	65	84
	4	2	1	½	15	21	26	18	28	33	26	36	45	33	50	66
	8	4	2	1	11	16	18	13	21	26	22	33	40	28	42	56
	16	8	4	2	9	12	15	11	18	21	18	30	36	24	38	46

Temperature gradient[4]: I, N, L.

[1]For open terrain. For heavily wooded terrain or jungle, multiply the figure obtained by 0.5 to obtain the appropriate expenditure.

[2]Blank spaces indicate excessive expenditures.

[3]An average of 50 percent casualties is expected among all troops who remain in the target area for the times specified.

[4]I=inversion, N=neutral, L=lapse.

[redacted]

S/C

DEPARTMENT OF THE ARMY FIELD MANUAL — FM 3–10B
NAVAL WARFARE INFORMATION PUBLICATION — NWIP 36–4
DEPARTMENT OF THE AIR FORCE MANUAL — AFM 355–9
MARINE CORPS MANUAL — FMFM 11–3B

EMPLOYMENT OF CHEMICAL AGENTS (U)

This copy is a reprint which includes current pages from Changes 1.

[redacted]

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DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE
NOVEMBER 1966

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CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. (U) Purpose

This manual provides classified data on chemical agents and on the capabilities and effects of chemical munitions. When used in conjunction with its unclassified counterpart, FM 3-10/NWIP 36-2/AFM 355-4/FMFM 11-3, Employment of Chemical and Biological Agents, it provides guidance in planning the employment of chemical munitions.

2. (U) Scope

This manual contains classified data on lethal agents VX and GB and incapacitating agent BZ; munitions effects tables; and predicted effects of ground-fired and air-released munitions utilized to disseminate these agents. As a joint publication, it discusses all appropriate chemical munitions of the U.S. Army, Navy, Air Force, and Marine Corps. Unclassified HD chemical munitions expenditure tables and guidance in chemical target analysis and casualty estimation are given in FM 3-10/NWIP 36-2/AFM 355-4/FMFM 11-3.

3. (U) Reliability

Data contained in this manual are based on proving ground tests and field tests, analytical studies of such data, and predictions extrapolated from mathematical models.

4. (U) Army, Navy, Air Force, and Marine Corps User Comments

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons for each comment should be provided to insure understanding and complete evaluation. Comments should be forwarded direct to the Commanding Officer, U.S. Army Combat Developments Command CBR Agency, Fort McClellan, Ala. 36205, with an information copy to the cognizant service doctrinal development agency.

Section II. ANTIPERSONNEL CHEMICAL AGENTS

[redacted]

6. (U) Incapacitating Agent BZ

This agent is disseminated as an aerosol to produce physical and mental effects when inhaled. The effects are temporary, and recovery is normally complete. There may be permanent ill effects in a few instances among the very young, the aged, and the infirm, or when massive dosages are received.

a. Tactical Employment. BZ is employed against carefully selected targets to incapacitate enemy troops when the use of lethal or destructive munitions is undesirable. This agent may be particularly useful in situations where adequate protective equipment is normally not available to enemy troops or where the status of training or mask discipline is poor, such as in counter-insurgency operations.

b. Limitations. BZ has the following limitations:

(1) The white agent cloud produced by pyrotechnic mixtures acts as a visible alarm.

(2) BZ may be defeated by improvised respiratory protection such as a folded cloth over mouth and nose.

(3) The effects are not immediate but require an average onset time of about 3 to 6 hours.

(4) There is no known antidote to treat affected friendly personnel.

c. Median Incapacitating Dosage (ICt_{50}). This is about 110 mg-min/m³ for man engaged in mild activity (breathing rate of 15 liters/min).

d. Physiological and Psychological Symptoms. The symptoms listed below will become more intense as the dosage received increases. They also vary according to the inherent characteristics of each individual exposed to the agent. Because of the many variables involved, estimation of the percentage and type of casualties produced from a BZ attack is difficult. Approximations for the occurrence of ultimate casualties among unmasked personnel are 5 percent in 2 hours, 50 percent in 4½ hours, and 95 percent in 9½ hours.

(1) Symptoms likely to appear in 30 minutes to 3 hours: dizziness, extreme drowsiness, dryness of the mouth, and increased heartbeat.

(2) Symptoms likely to appear in 3 to 5 hours: restlessness, involuntary muscular movement, near vision impairment, and physical incapacitation.

(3) Symptoms likely to appear in 6 to 10 hours: hallucinations, lack of muscular coordination, disorientation, and difficulty in memory recall.

e. Duration of Incapacitation. The duration of incapacitation varies with the dosage received—from 24 hours to 5 days.

f. Duration of Effectiveness. Under average meteorological conditions in the open, the aerosol is normally effective for only a few minutes after dissemination, since the fine BZ particles travel

[redacted]

27. (U) CBU-5B/M43 750-Pound BZ Cluster Bomb

Both the U.S. Air Force CBU-5B and the U.S. Army M43 750-pound cluster bombs contain 57 M138 BZ-filled bomblets. The U.S. Army M43 cluster is designed for delivery by aircraft at low speeds. When modified and equipped with a suitable fairing for streamlining purposes, an internal arming wire system, and a strengthened tail fin, it is then designated the CBU-5B and can be delivered by high-performance aircraft.

a. Operational Concepts. The BZ cluster bomb is used on carefully selected targets against enemy personnel when the use of lethal chemical or destructive weapon systems is militarily or politically undesirable. See paragraph 6 for additional data.

[redacted] 47

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b. Characteristics. The cluster contains about 85 pounds of agent BZ and employs two tail mechanical time fuzes. To function properly, the cluster must be released above 6,200 feet so as to allow the cluster to open at approximately 4,500 feet. The M138 bomblet contains four canisters, each with three-fourth pound of agent-pyrotechnic mixture (50/50 ratio), and an "all-ways" impact fuze. The bomblet is *not* self-dispersing.

c. Capabilities. The cluster delivers M138 bomblets over an elliptical impact area having a cross section of approximately 100 by 200 meters when released at heights above 6,200 feet. One cluster can cover about 12,000 square meters (1.2 hectares) with an incapacitating total dosage of BZ (110 mg-min/m^3) under neutral temperature gradient and in a wind speed between 2 and 10 knots; under lapse temperature gradient conditions, the area coverage will be smaller. Under optimum delivery conditions, the area coverage for one cluster is expected to range from 15,000 to 20,000 square meters. Field tests indicate that wind speed has only minor effects upon area coverage.

d. Operational Considerations. Refer to the appropriate technical order/flight manual to determine aircraft loads (see para 16*d*).

[redacted]

Field Manual
No 3-6

Air Force Manual
No 105-7

Fleet Marine Force Manual
No. 7-11-H

HEADQUARTERS
DEPARTMENT OF THE ARMY
DEPARTMENT OF THE AIR FORCE
UNITED STATES MARINE CORPS
Washington, DC, 3 November 1986

FIELD BEHAVIOR OF NBC AGENTS (INCLUDING SMOKE AND INCENDIARIES)

Table of Contents

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DISPERSION CATEGORY	ATMOSPHERIC DESCRIPTION	TRADITIONAL ATMOSPHERIC CONDITIONS
1	Very Unstable	Lapse
2	Unstable	Lapse
3	Slightly Unstable	Neutral
4	Neutral	Neutral
5	Slightly Stable	Neutral
6	Stable	Inversion
7	Extremely Stable	Inversion

Figure 1-1. Atmospheric stability categories and conditions.

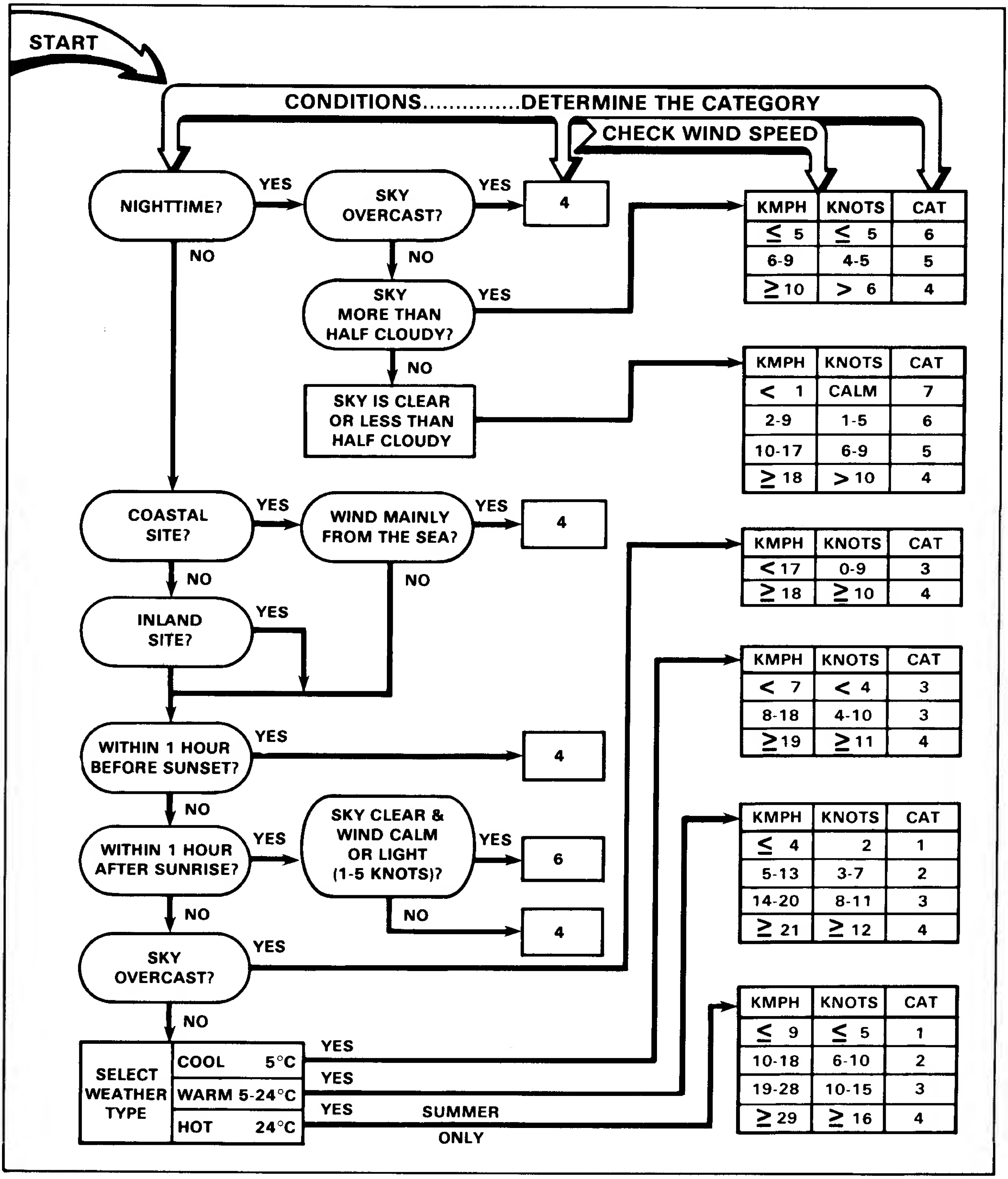

Figure 1-2. Stability decision tree.

Page 1-14 states that the mixed air layer height is 50-100 m on a clear, calm night, just before 400 m before sunrise, and 2 km on a hot summer day

Table 1-3. Center line dosages at different distances downwind for different dispersion categories and wind speeds for a unit source. 100 kilograms of GB

Stability Category	Wind Speed	Downwind distance in km: .5	1	2	4	6	10	20	30
		DOSAGES (mg-min/M³)							
1	1	57.82	10.960	2.4820	1.2070	.8048	.48290	.24140	.16100
1	3	19.15	3.628	.8224	.3998	.2665	.15990	.07995	.05330
1	5	11.47	2.174	.4928	.2396	.1597	.09582	.04791	.03194
2	3	65.93	16.480	4.121	1.0300	.4671	.22840	.11360	.07575
2	6	32.86	8.215	2.054	.5135	.2328	.11380	.05663	.03775
2	10	19.75	4.938	1.235	.3087	.1400	.06843	.03404	.02269
3	3	172.60	46.26	12.400	3.321	1.5370	.5825	.18010	.11510
3	7	73.86	19.79	5.302	1.421	.6576	.2492	.07703	.04925
3	12	43.09	11.55	3.094	.829	.3837	.1454	.04494	.02874
4	3	572.4	170.20	50.590	15.040	7.398	3.0260	.8997	.44450
4	8	213.9	63.61	18.910	5.622	2.765	1.1310	.3363	.16620
4	16	107.1	31.84	9.467	2.814	1.384	.5662	.1683	.08318
5	2	1,837.0	606.0	199.90	65.94	34.470	15.220	5.021	2.6250
5	5	736.2	242.9	80.12	26.43	13.810	6.101	2.012	1.0520
5	9	408.7	134.8	44.47	14.67	7.668	3.387	1.117	.5839
6	1	10,080.0	3,691.0	1,351.0	494.50	274.70	131.00	47.930	26.630
6	3	3,339.0	1,222.0	447.4	163.80	90.96	43.37	15.870	8.818
6	5	2,001.0	732.4	268.1	98.12	54.51	25.99	9.5120	5.284
7	HIGHER DOSAGES THAN ABOVE								

Table 1-4. Summary of favorable and unfavorable weather and terrain conditions for tactical employment of chemical agent vapor or aerosol. (The stability condition listed for the south slope is for the northern hemisphere; due to solar loading on the slope, the situation would be reversed for the southern hemisphere.)

FACTOR	UNFAVORABLE	MODERATELY FAVORABLE	FAVORABLE
Wind	Artillery employment if speed is more than 7 knots. Aerial bombs if speed is more than 10 knots.	Steady, 5 to 7 knots, or land breeze.	Steady, less than 5 knots, or sea breeze.
Dispersion Category	Unstable (lapse).	Neutral.	(Stable) inversion.
Temperature	Less than 4.4°C.	4.4° to 21.1°C.	More than 21.1°C.
Precipitation	Any.	Transitional.	None.
Cloud Cover	Broken, low clouds during daytime. Broken, middle clouds during daytime. Overcast or broken, high clouds during daytime. Scattered clouds of all types during daytime. Clouds of vertical development.	Thick, low overcast. Thick, middle overcast.	Broken, low clouds at night. Broken, middle clouds at night. Overcast or broken, high clouds at night. Scattered clouds of all types at night. Clear sky at night.
Terrain	Hilltops, mountain crests. South slopes* during daytime.	Gently rolling terrain. North slopes at night.	Even terrain or open water.
Vegetation*	Heavily wooded or jungle.	Medium dense.	Sparse or none.

*Cloud dissemination occurs above the canopy.